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OF THE

AMERICAN CERAMIC SOCIETY

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Photo courtesy The Metropolitan Museum of Art

The high-fired stoneware vases shown in this illustration are examples of the work of Charles Fergus Binns. The high temperature at which these pieces were fired enabled Dr. Binns to obtain interesting effects from rare oxides which do not function at the lower firing temperatures used for faience. The finished workmanship and glazes of these pieces are of chief interest. An account of the Memorial Service for Dr. Binns at Alfred, New York, June 8, is given on page 241.

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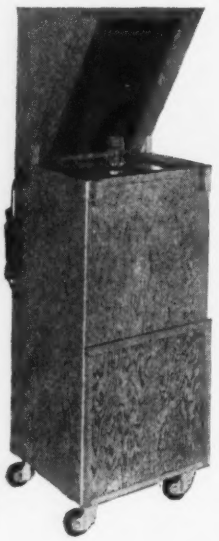

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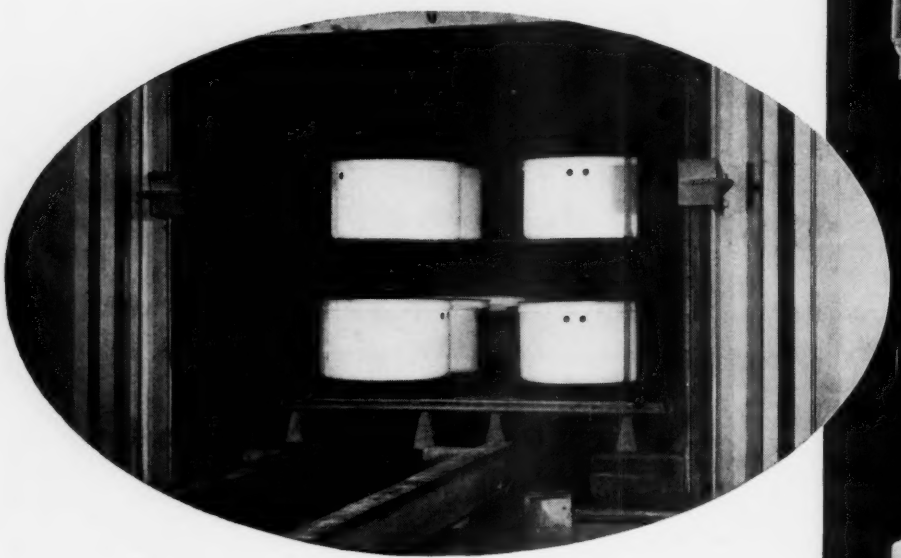

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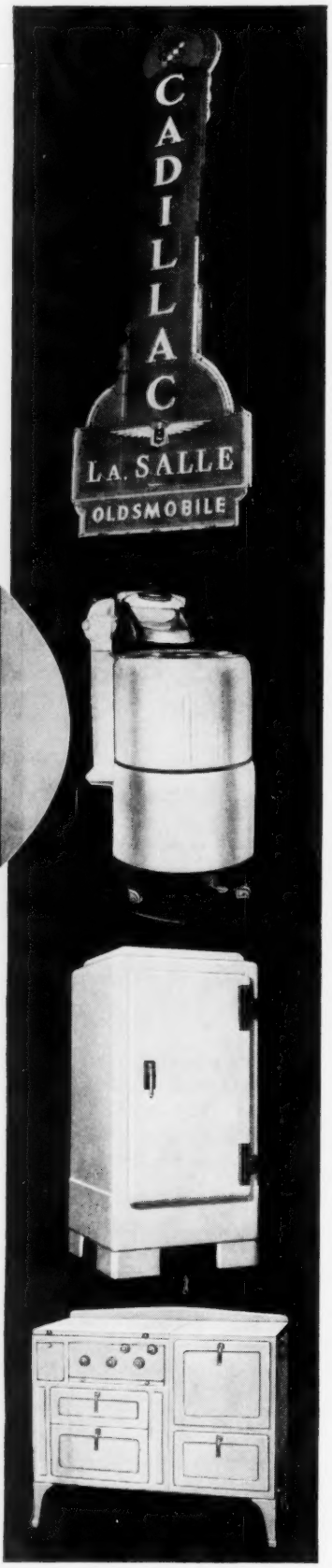

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THE BULLETIN OF THE AMERICAN CERAMIC SOCIETY

A Monthly Publication Devoted to Proceedings of the Society and Promotion of Coöperative Research of Technical, Scientific, and Art Questions

Vol. 14 **July, 1935** **No. 7**

PAPERS

SOME USES OF ELECTRIC FURNACES FOR CERAMIC FIRING*

By E. J. Harris† and B. A. Bovée‡

Abstract

The design and operation of small periodic electric furnaces is presented, discussing heating and cooling cycles and control, both electric and thermal. Types of ware being fired and the kiln furniture used are described. The cost of operation is shown, based on prevailing electrical power rates, including figures on energy consumption per pound of ware fired.

I. Introduction

The firing of ceramic ware is, in general, conceded to require atmospheric circulation, oxidizing conditions, and temperatures usually well over cone 02 or the limit for the usual metal resistors.

Silicon-carbide resistors are now commercially available which are well adapted to fire as high as cone 16 in highly oxidizing atmospheres.

The furnaces cited in this discussion are small and are chiefly useful in firing specialties. The results obtained with them have been favorable and indicate definitely the practicability of electric firing of ceramic ware.

II. Method of Mounting the Elements

The live wires are not attached directly to the elements, but to external terminals which extend into the furnace walls to make contact with the ends of the heating elements.

Water-cooled terminals are used for all temperatures up to the limit for the elements and in furnaces of all sizes and ratings.

Figure 1 shows typical cross-sections of two furnaces in each of which the element is mounted horizontally. The section to the left shows a water-cooled terminal and the one on the right, an air-cooled terminal. The terminal in either case is held in position against the end of the heating element by a terminal mounting attached to the frame of the furnace. A coiled spring, acting on a third-class lever, presses the terminal firmly against the end of the element. Electrical connections may be made to the terminal or to an insulated stud fastened to the terminal lever. Springs are usually placed on both sides of the furnace to increase the flexibility of the mounting although it is only necessary to have them on one side.

The heating elements may also be mounted in a vertical position. The principle of mounting is essentially the same in both cases.

In the case of the furnaces described here, the elements were mounted in a horizontal position.

III. Description of Furnace

Figure 2 shows sections through the furnace. The firing chamber is 30 in. long, 30 in. wide, and 26 in. high. The hearth size is 16 by 30 in., and the maximum loading height is 17 in. The elements are 34 in. long and $1^1/_4$ in. in diameter

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Symposium on Ceramic Ware Firing). Received February 19, 1935.

† The Carborundum Co., Niagara Falls, N. Y.

‡ Globar Corp., Niagara Falls, N. Y.

** Page 218 of Volume 14 of *The Bulletin of the American Ceramic Society* will be omitted because of a conflict with the advertising pages in the June issue.

and are rated at $11^1/_2$ kw. in free air when operated on their rated potential of 110 volts.

There are four elements on each side of the firing chamber spaced 5 in. apart in the vertical plane. Tubes are built into the bottom and top of the furnace to obtain a circulation of air or other gases through the firing chamber. Three tubes extend from a slot in the furnace floor.

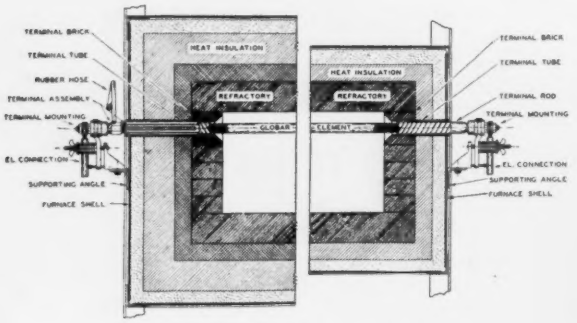

FIG. 1.

Swing dampers regulate the rate at which air is admitted. The two openings in the top for the escape of gases can be closed with plugs if necessary.

The eight elements are interconnected by a series of switches by means of which various heating rates can be obtained.

The furnace walls were $13^1/_2$ in. thick. The lining was of fire brick, backed up with $4^1/_2$ in. of insulating refractory brick and $4^1/_2$ in. of insulating brick. An opening, $1^1/_2$ by 5 in., was built into each side wall at the floor level, and two openings 4 in. square were built into the crown. These openings are intended (1) to aid circulation of the atmosphere during firing and (2) to facilitate cooling.

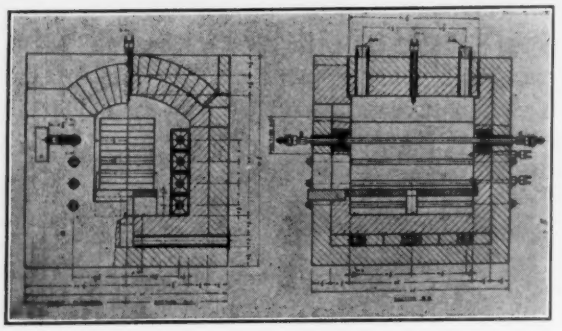

FIG. 2.

IV. Securing Atmospheric Turbulence

This furnace did not have the necessary circulation of atmosphere to produce ware that was clear throughout its cross-section unless such an open setting was used that a very large part of the available loading space was wasted.

Several alterations were made in an effort to produce greater turbulence of the atmosphere, but the results were unsatisfactory until a small jet of steam was directed through the hearth toward the top of the furnace. With a very gentle jet of steam for one-half hour at approximately 1200°C (near the vitrification range), it was possible to produce satisfactory ware, free from coring, and of the proper strength. The steam was injected at such a rate that the furnace temperature remained constant or dropped only slightly throughout the half-hour period. During this period the vapor could be seen escaping from the opening around the door and upper terminal blocks. It was also found that the finishing temperatures of some of the runs could be lowered about 30°C.

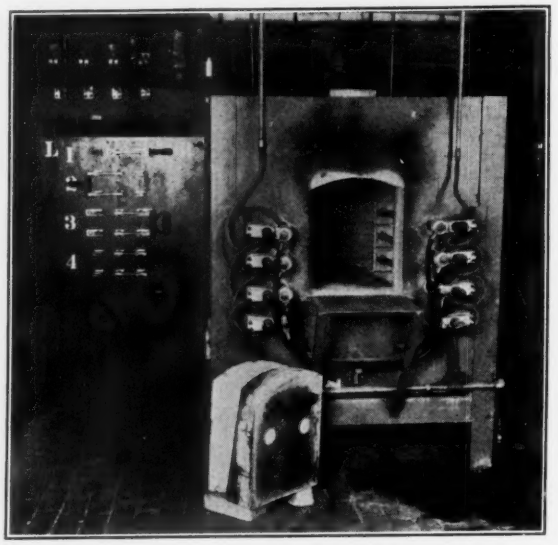

FIG. 3.

Increased circulation of the furnace atmosphere can also be obtained by the use of a jet of air or other gas.

It was noted that while a furnace with a firebrick lining was rugged it did not lend itself to rapid cooling and that it used up too much heat during the firing period.

Figure 3 shows a furnace which has walls only

9 in. thick, $4^1/_2$ in. of lightweight insulating refractory brick inside, and $4^1/_2$ in. of insulating brick outside. The walls of the firing chamber are given a brush coating of refractory cement to protect them from abrasion and to increase the life of the brick. The panel on which the switches and magnetic contactor are mounted can be seen at the left.

Figure 4 shows a typical firing and cooling curve for this type of furnace. It also shows the steps or different kilowatts of power input used during firing and gives the estimated and actual kilowatt hours consumed. The flat spot near 1200°C shows when the steam was injected.

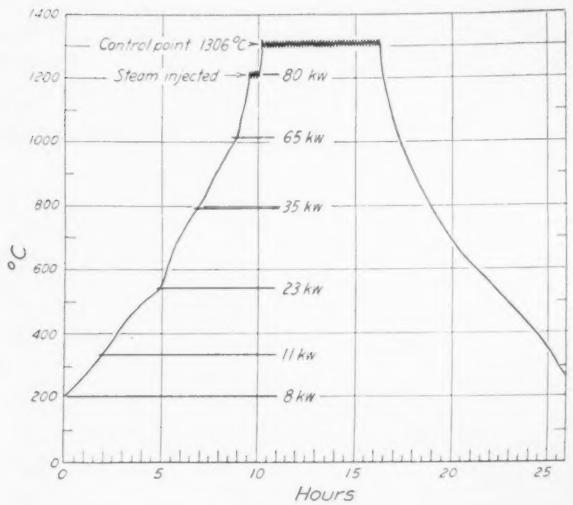

FIG. 4.—Firing and cooling curve; kilowatts shown are estimated amounts. Estimated kw.-hr. = 453. Actual kw.-hr. = 400.

The finish temperature, approximately 1310°C, was maintained for six hours. It also shows how rapidly the furnace can be cooled.

V. Firing Small Abrasive Wheels

The present loading practice consists of setting the ware either open or buried in sand as required in silicon-carbide saggers, $10^1/_2$ by $12^1/_2$ in. These saggers have walls and bottoms $^1/_2$ in. thick and are made up in three depths as can be seen in Fig. 5. The $^1/_2$-in. space between the saggers is sufficient for most of the ware. The saggers are stacked up on the door shelf of the furnace and the entire stack is pushed into position. After firing, the stacks are pulled out onto the shelf again by means of metal hooks. Larger pieces of course have to be set in various ways.

Figure 6 shows a set of Orton cones which were placed in saggers in the furnace just shown. Each bat contains cones 12, 13, 14, and 15. Four bats were placed (as shown) in the bottom.

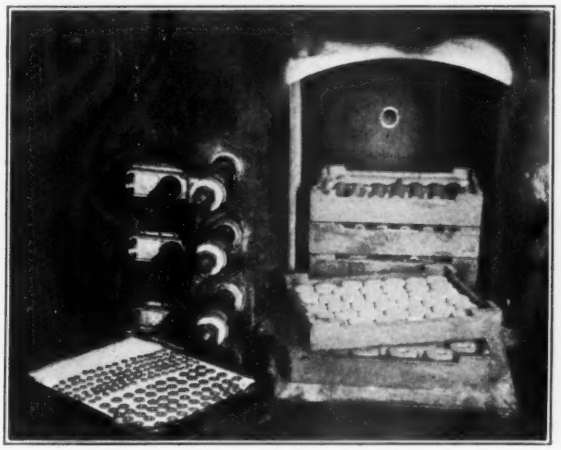

FIG. 5

middle, and top of a stack 17 in. high and were fired to a maximum temperature of 1340°C. This temperature was maintained for six hours. Steam was injected for $^1/_2$ hour at 1200°C. The

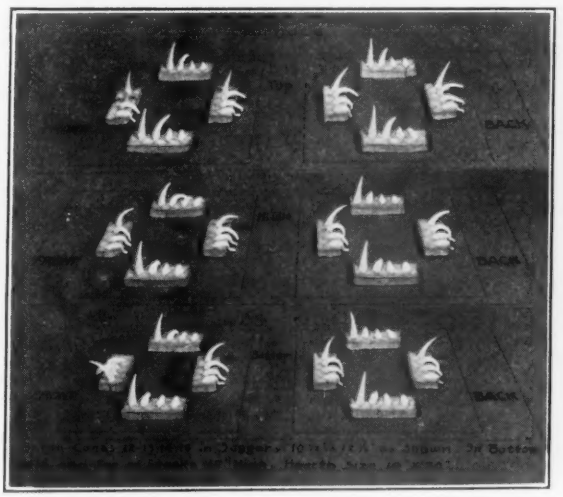

FIG. 6.—Cones from Globar furnace. Orton cones 12, 13, 14, and 15 in saggers $10^1/_2$ x 12 inches as shown. In bottom, middle, and top of stacks, 17 inches high; hearth size 14 by 30 inches.

maximum variation is about two-thirds of a cone.

The original purpose in building these furnaces was to provide emergency units for rush or experimental orders. It was found, however, that the results obtained with certain types of ware warrant their use as production units.

VI. Cost of Operation

The approximate cost of operating this last furnace has been calculated on a basis energy at $^1/_2$ cent, 1 cent, and $1^1/_2$ cents per kilowatt-hour. The usual charge or load consists of 210 lb. of ware and kiln furniture. The average net charge of ware is 45 lb. The costs based on 75 heat runs per set of elements are as follows.

On basis of energy at \$0.005 per kilowatt-hour, the costs are as follows:

Energy cost	\$2.00
Element cost	1.58
Terminal cost	0.0568
Total	\$3.6368 or \$3.64

The cost per pound of ware and kiln furniture is \$0.017.

On basis of energy at \$0.01 per kilowatt-hour, the cost per pound of ware and kiln furniture is \$0.027.

On basis of energy at \$0.015 per kilowatt-hour, the cost per pound of ware and kiln furniture is \$0.036.

These costs are about one-half as great as those incurred in the furnace of the same chamber dimensions but constructed with a firebrick lining.

The estimated cost of a furnace similar to those described but built by a commercial furnace builder is about \$1600.

The switchboard, magnetic contactor, and automatic temperature controller are extra. Their cost will depend upon the method of controlling the power input, the voltage of the power supply, and other factors.

A transformer with a selected number of secondary taps can be used in place of a power-timing control or can be used in conjunction with it.

VII. Summary

The experience obtained with the furnaces described indicate that (1) ceramic ware can be fired satisfactorily in silicon-carbide resistor furnaces in the temperature range from 1200 to 1500°C; (2) the firing cost per unit weight total load is not unreasonable for a small batch furnace; (3) the effects of stagnant atmosphere usually associated with electric firing can be overcome by induced circulation; and (4) the turbulence of the kiln atmosphere is not necessary throughout the entire run.

CONTROL OF ATMOSPHERE IN KILNS*

By M. H. Mawhinney

I. Introduction

The purpose of this paper is to discuss the control of atmosphere in gas- and oil-fired kilns for firing ceramic ware, with the realization that the control of atmosphere is not the entire answer to the problem of quality of ware; the control of the ceramic body to suit the best atmosphere obtainable is equally important. This phase of the subject, however, is not included in this paper.

The ceramic industry can, to a greater extent, take advantage of the developments in atmosphere control, which of necessity have been brought to a high degree of perfection in the heating of metals in the steel and nonferrous metal industries. Methods of obtaining a thoroughly mixed and homogeneous atmosphere will be pointed out.

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Symposium on Ceramic Ware Firing). Received March 3, 1935.

(1) What Is "Atmosphere?"

In addition to those gases which are given off by the ware, the atmosphere in any direct-fired kiln consists of the products of combustion of the fuel burned. Since all fuels are hydrocarbons, the gaseous products of combustion are almost exactly the same for all fuels and vary only in relative proportions. For theoretically perfect combustion, the only products from any fuel are CO_2, water vapor, and N_2. To one side of this perfect line lies the range of oxidizing atmospheres, obtained by an excess of combustion air and indicated by free O_2 in the products. To the other side of the line are reducing atmospheres, resulting from a deficiency of combustion air and indicated by the appearance of CO, methane or other unburned gases, and H_2 in the flue analysis.

The above discussion presupposes a homogeneous atmosphere obtained by thorough mixing of fuel and air. In actual ceramic practice, it

is too often possible to find both free O_2 and the reducing agents (CO, H_2, and unburned gases) in the same analysis, which condition indicates strata of gas and air resulting from improper mixing of fuel and air.

In most ceramic practice, oxidizing atmospheres are necessary to oxidize the chemicals of the ware, and reducing gases, even in small quantities, account for spoiling much ceramic ware and for many of the inconsistent results which are experienced in kiln operation.

The maintenance of a positively oxidizing or reducing condition in a kiln, in spite of improper mixing of fuel and air, is possible by the use of a large excess quantity of air or fuel, as the case may be. Either practice, however, is definitely wasteful of fuel and is economically unsound in any competitive industry where fuel costs are important. It is obvious that a homogeneous atmosphere of the desired analysis to produce satisfactory ware and maintained with a minimum of fuel is the desirable combination.

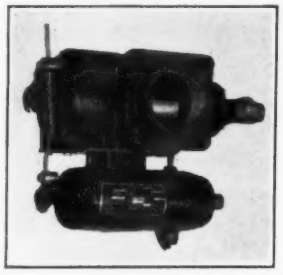

FIG. 1

The nature of atmosphere obtained in a direct-fired kiln or in a furnace and the economy of operation are determined by the following principal factors: (1) control of primary air quantity, (2) control of secondary air quantity, and (3) mixing of air and fuel before and during ignition.

II. Control of Primary Air

The total quantity of air used in a kiln per unit of time is determined by the quantity of fuel burned, the air required by each unit of the fuel for combustion (a chemical problem), and the minimum excess or deficiency of air which produces the atmosphere analysis necessary to produce satisfactory ware. By primary air is meant that part of the total air which enters the kiln through the burners or combustion device in direct contact with the fuel. In the opinion of the author, the primary air should represent as large a part of the total as can be obtained, to insure the best atmosphere and fuel economy.

This primary air may be measured into the kiln by manual adjustment of valves or by automatic devices for maintaining a constant ratio of air to fuel at all rates. The weakness of the first method needs no comment. Several types of automatic mechanisms are shown in Figs. 1 to 3.

Figure 1 shows a mechanical device, consisting of fuel and air valves mounted on a common rotating shaft. Having adjusted the desired relative widths of openings, the relative areas of opening remain constant for all settings. With constant relation of areas and with provision for constant fuel and air pressures, the relative rates of fuel and air flow remain constant. The valve for oil or gas fuel may be operated by hand or by a motor, as shown for use in conjunction with temperature-controlling pyrometers.

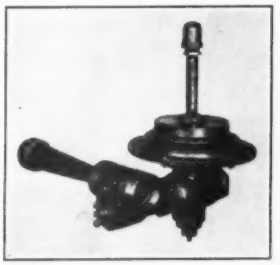

FIG. 2.

Figure 2 shows a typical proportioning mixer of the inspirating type for gas. In this device the sensitive regulator permits the entrance of sufficient gas at all times to just balance the suction of the inspirator, which varies with the rate of air flow. The flow of gas is therefore automatically regulated by the flow of air and a constant air-gas ratio is maintained.

FIG. 3.

Figure 3 illustrates a fan-type mixer, in which an automatically proportioned mixture of air and gas passes through the blower and is supplied under pressure to the kiln.

The illustrated mechanisms are typical of a large number of such reliable devices which may be obtained for eliminating the variations which must result from the manual adjustment of fuel-air rates.

III. Control of Secondary Air

The secondary air in a kiln or furnace is the difference between the total air requirements and the primary air entering through the burners. In metallurgical practice, if close atmosphere

control is desired, it is universal practice to admit all air as primary air and exclude all other air, because only by this method can true uniformity of atmosphere be obtained.

In ceramic practice, the advantages of control of secondary air in atmosphere control and economy are not generally recognized. Excessive stack draft, which is difficult to control accurately, is frequently utilized to insure a sufficient quantity of air, with consequent stratified atmospheres and waste of fuel.

Whether all secondary air is to be excluded or a quantity of secondary air is to be admitted, the only method available is pressure control. Comparatively simple apparatus is available, which will reliably hold the pressure in a kiln or furnace to within ± 0.005 in. of water pressure or draft and, when properly applied, will usually produce a remarkable improvement in operation.

IV. Mixing of Air and Fuel

The measurement and control of relative quantities of air and fuel have already been discussed. The question of the degree or thoroughness of mixing of fuel and air before and during ignition involves both the burner equipment and the design of the kiln.

The types of burner equipment, with reference to efficiency in fuel mixing, may be roughly divided as follows:

(1) Two-Pipe or Blast Burners

All oil burners and many gas burners are of this type. The fuel and air come to the burner through separate pipes and do not mix until they meet inside of the burner. They are in contact for only a brief instant and at comparatively low velocities, so that the degree of mixing, in the case of gas fuels, is not as great as is possible in other types of burner equipment. Such burners are mounted outside the furnace and fire through an opening in the furnace wall. Secondary air, under poor control and in indifferent contact with the fuel, is drawn through this opening. The quantities of fuel and air may be accurately maintained by a valve such as shown in Fig. 1.

(2) High-Pressure Burners

These are burners where gas at 15 to 25 lb. per sq. in. injects air from the atmosphere. They are usually sealed in the wall to eliminate all secondary air. The time of mixing is again very short, but the high pressure of the gas releases sufficient energy for a good degree of mixing.

(3) Low-Pressure Tunnel Burners

Such burners are sealed in the walls and all air enters through the burners. The mixture is measured and mixed by such devices (as shown in Fig. 1) with a Venturi mixer attached or a mixer as shown in Fig. 2. The mixture becomes thoroughly mixed by turbulence and by impacts in passing through the manifolds to the burners, and enters the furnace with a high degree of mixing. Mixture pressures are from 4 to 8 oz. per sq. in.

(4) High-Pressure Tunnel Burners

These burners are sealed in the wall and supplied with a gas mixture at a pressure of from $^1/_2$ to 1 lb. per sq. in. The mixture is supplied by a blower-type mixer (Fig. 3). With the higher pressure the mixing action in the manifolds is extremely vigorous, and this system supplies the most complete degree of mixing of any type of equipment.

When it is realized that to prevent backfiring or burning-back in the burners with any of the above gas-burning systems, a velocity of from 15 to 30 ft. per second (depending on the fuel) is necessary, it can readily be seen that the interval of time elapsing before the igniting mixture strikes the ware is extremely small in any direct-fired arrangement. This time interval is so small that if the flame is not baffled, the chemical process of combustion will not be complete and reducing conditions may exist at the surface of the ware, in spite of proper air-gas ratio and high degree of mixing.

This baffling within the kiln must be accomplished with as simple a kiln design as possible to prevent costly maintenance which will result from any complicated or fragile refractory design. Common methods employed are (1) firing above and below the ware, (2) arrangement of setters to prevent direct impingement, and (3) dog houses or bag walls to change the direction of the burning mixture and thereby reduce its velocity.

The best results are obtained when a satisfactory and uniform product is produced in an atmosphere requiring the minimum amount of fuel and in a kiln of the most simple and rugged design, which will insure the required atmosphere.

Salem Engineering Company
Salem, Ohio

OXIDATION OF CERAMIC WARE DURING FIRING. VII. REVIEW*

By Frederick G. Jackson

Note: Ten years ago the writer presented a series of papers[1] that seemed, at the time, to cover the subject of oxidation of ceramic ware during firing. Subsequent observations and meditations have brought the conclusion that they fell far short of the mark. They were written as the work progressed, without unity of vision, or, at first, without a definite idea of how they would conclude. The fundamental principles discovered were not sufficiently brought out and harmonized. A definite variable was completely overlooked.

It is with the hope of making a more useful and comprehensible unit of the research that this review of the subject is undertaken.

I. Object

In firing ceramic ware, it is not the clay that makes the difficulty, but the undesirable impurities that are in it, such as oxidizable sulfur, carbon, and compounds and mixtures of lime and magnesia such as carbonates and sulfates.

The circumvention of the undesired impurities, sulfur and carbon, is the main object of this work.

II. A Theoretical Simple Apparatus

Using all of the results previously presented[1] and later observations on industrial kilns, consideration is given to what can happen when a body of clay containing pyrite[2] is heated. The simplest conceivable system may be used and the necessary complications of industrial practice will be added one at a time.

To illustrate, a theoretical, very small body of clay containing pyrite can be used, enclosed in a refractory container and subjected to a current of partly oxidized heated air. The rate of flow of the air and the rate of increase of its temperature are supposed to be flexible and under complete control.

(1) Variables

With such an apparatus a large number of different experiments can be made, because four variables present themselves: (1) rate of flow of the heated gases, (2) rate of increase of temperature of the heated gases, (3) resistance to gas penetration of the particular clay employed, and (4) percentage of sulfur as pyrite. These first two can be combined into a single varying ratio, *i.e.*, the rate of flow to the rate of temperature increase of the gases. Variable 3 can be eliminated temporarily by considering that the first series of theoretical experiments has been made with clays of approximately the same resistance to gas penetration with the sulfur content fixed at first at about 0.50% S.

(2) Varying Rate of Flow per Rate of Temperature Increase of Gases

Thus a clay body of a physical and chemical type frequently used may be tested in a theoretical "kiln" with a perfectly flexible and controllable draft and heating schedule. The first theoretical firing could be made with a good draft and a slow rate of heating. There is no doubt of what would happen. When the temperature approached 425°C, a reaction would take place, a combination of $4FeS_2 + 11O_2 = 2Fe_2O_3 + 8SO_2$ and of $4FeS_2 + 15O_2 = 2Fe_2O_3 + 8SO_3$, which would eliminate practically all the sulfur from the clay without delay.

If, in a series of such theoretical experiments, the draft were reduced by regular graduations while the heating schedule was being successively speeded up, the effect would be that of progressively reducing the supply of oxygen available per unit rise of temperature of the gas. The unknown and previously unconsidered factor enters here, *i.e.*, the specific resistance to gas penetration of the clay. Whatever this is, in these experiments it is assumed to be constant.

When the supply of oxygen is so reduced that it cannot penetrate the clay body and oxidize and remove all of the sulfur between the temperatures

* Received April 8, 1935.

[1] The laboratory work on which this paper is based was performed at the Ceramic Station, U. S. Bureau of Mines, Columbus, Ohio, during the years 1923 to 1925. For the published series of papers, see G. A. Bole and F. G. Jackson, "The Oxidation of Ceramic Ware During Firing, I," *Jour. Amer. Ceram. Soc.*, **7** [3] 163–74; F. G. Jackson, II, *ibid.*, [4] 223–37 and [5] 382–96; III, [6] 427–29; IV, [7] 532–38; V, [8] 634–42 and [9] 656–62 (1924); VI, **8** [8] 534–40 (1925).

The behavior of the clay samples was studied in a quartz combustion tube 1 inch in diameter, heated in an electric furnace, in a miniature round downdraft kiln 8 inches high and 15 inches in diameter, and in a series of commercial kilns selected for their firing time and for the sulfur content of their fuel. This study has been supplemented by later observations of commercial kilns and a digestion of the subject.

[2] Pyrite (FeS_2) is selected as the source of sulfur since it is much the commonest form in which oxidizable sulfur occurs in clay. The sulfates of lime and magnesia, also commonly occurring, are unaffected by firing except at very high temperatures.

of approximately 425°C and 500°C, a different action takes place. To study this, we must take the above reactions to pieces. It is known that pyrite will decompose in a nonoxidizing atmosphere at about 425°C as follows: $FeS_2 = FeS + S$.[3] This free elemental sulfur would be liberated as a vapor into the kiln atmosphere. Hence it would have first chance at the oxygen of the kiln atmosphere and would be the first to oxidize: $S + O_2 = SO_2$. The remaining FeS, still a solid distributed through the clay, could combine with oxygen in a number of ways, depending on the temperature and the amount of oxygen available:

$$FeS + 2O_2 = FeSO_4$$
$$6FeS + 13O_2 = 2Fe_2(SO_4)_3 + 2FeO$$
$$4FeS + 7O_2 = 2Fe_2O_3 + 4SO_2$$
$$4FeS + 9O_2 = 2Fe_2O_3 + 4SO_3$$

Once ferric sulfate is formed, it may persist undecomposed to a somewhat higher temperature before decomposing by the reaction $Fe_2(SO_4)_3 = Fe_2O_3 + 3SO_3$. This might result in the ferric oxide thus formed entering into a different silicate combination with a lighter color than ferric oxide that was free at lower temperatures. At least, this is the accepted explanation for "pink spot" and "pink core." Pink spot is formed when sulfuric acid drips on the ware during an early stage of firing. This will be discussed later.

Ferrous sulfate is also apparently stable, and therefore is formed, at temperatures above 500°. Unfortunately for the ceramist, it readily combines with free silica to form ferrous silicate, a low-melting black glass. Whether or not a compound such as ferrous sulfosilicate or only a solid solution is formed is difficult to determine. In either case, this action forms a viscous layer below the surface of the ware which tends to fill its pores and prevent further penetration of oxygen. Oxidation can therefore take place only on the surface of this viscous layer and will penetrate slowly, even though plenty of oxygen is available as firing proceeds.

If ferrous sulfate persists inside this viscous envelope until the system reaches the temperature at which $FeSO_4$ decomposes of its own accord (which is below the normal finishing temperature), a gas will be liberated suddenly throughout the body. Since this gas cannot readily penetrate its enclosing envelope it develops a pressure. This pressure expands the envelope and the ware until the envelope breaks and releases the pressure. Such black bloated "clinker brick" are common sights around brick plants where the clay contains much sulfur. There has been developed a commercial demand for these "clinkers" for ornamental chimneys, fireplaces, etc.[4]

In these theoretical experiments, it can thus be determined how rapidly the clay may safely be heated through the oxidizing stage with a rate of gas flow attainable in commercial practice. This safe rate of heating will vary with the percentage of sulfur in the clay and with the specific time of gas penetration of the particular clay used.

III. Carbon in Clay

Carbon frequently occurs naturally as an impurity in clay. It is almost always associated with pyrite, since the reducing conditions during deposition of the clay bed that would be necessary for carbon to persist would also favor pyritic formation.

Sometimes carbon is added to clay. The makers of common brick in the Hudson River district mix in sawdust. This, if used in moderation, saves fuel in firing and makes a lighter, more porous brick.

NOTE: The writer once visited a plant that had no problem from carbon or sulfur in the clay. The superintendent had heard of using sawdust and experimented by adding fuel oil to the clay. He pushed his experiment too fast, however, and had to abandon two kilns with the charges undrawn. The top of each setting had settled like a saucer to a maximum depth of four feet. The setting had fused into a single black mass.

It is a common misbelief that "the black is carbon." This is not the case.[5] Carbon burns too avidly to persist in most cases. Red-firing clays generally contain 3 to 7% of iron oxide as well as much free silica. What probably had

[3] This has been proved at several plants. A cold iron bar is thrust through an opening near the bottom of the wicket at the right stage. When removed after a few minutes, it is found to be coated with elemental sulfur crystals.

[4] As a consultant, the writer was once employed to increase the percentage of clinker output, which the plant sold at an advanced price. A sudden wave of popularity had carried away a ten-years' accumulation. Not many plants are so fortunate.

[5] The easy but fallacious reasoning, "there is carbon in the clay; carbon is black; the core is black; therefore the core is carbon," was disproved by Edward Orton, Jr., in "The Rôle of Iron in Clay Firing," *Trans. Amer. Ceram. Soc.*, **5**, 407 (1903), and since then has had little scientific support. Fully half the kiln firemen, however, with whom the writer has talked believe that "the black is carbon." To see how easy it is to fall into this error, see R. E. Arnold and G. H. Duncombe, Jr., "Clay Sewerpipe Manufacture," VII, *Jour. Amer. Ceram. Soc.*, **12** [6] 425 (1929).

happened in these kilns was $C + 2Fe_2O_3 = 4FeO + CO_2$ and $xFeO + ySiO_2 = (FeO)x(SiO_2)y$. The ferrous silicate had melted sufficiently to run the charge into one mass, allowing it to settle.

IV. Carbon and Sulfur in Clay

When carbon and sulfur are both present in clay, the carbon burns out first. Experiments, however, have shown that the pyrite ignites first. This ignites the carbon, which has a higher ignition point but a greater affinity for oxygen. Consequently the oxidation of the sulfur is delayed until enough oxygen has penetrated the ware to oxidize all the carbon. If the temperature of the atmosphere of the kiln is being increased as time goes on, the sulfur must oxidize at a higher temperature. This increases the chance of forming sulfates, with consequent trouble. The heat generated by the burning carbon and the heat from the burning of sulfur also raise the temperature.

V. Heat of Reaction

The above chemical reactions that have been discussed so far have not been complete because they have been accompanied by the evolution of heat as well. Properly, the following reactions should be written:

$$C + O_2 = CO_2 + 94{,}000 \text{ cal.}$$
$$4FeS_2 + 11O_2 = 2Fe_2O_3 + 8SO_2 + 520{,}800 \text{ cal.}$$
$$\text{or } FeS_2 + \frac{11O_2}{4} = \frac{1}{2}Fe_2O_3 + 2SO_2 + 130{,}200 \text{ cal.}$$

This means that 12 grams of carbon, when combining with 32 grams of oxygen give off 94,000 calories of heat. One calorie will raise the temperature of one gram of water 1°C. Similarly 120 grams of FeS_2 (or 64 grams of sulfur as FeS_2), in oxidizing as noted above, will generate 130,200 calories. This seems like a tremendous amount of heat and its meaning will be examined. If the clay contains 1% of carbon, there will be 1 gram of carbon in 100 grams of clay. This 1 gram of carbon in oxidizing will give off $\frac{94{,}000}{12} = 7833$ cal. This would raise 100 grams of water 78.33°C. But clay has a specific heat of about 0.40. Therefore the oxidation of 1% of carbon in clay would (theoretically) raise the temperature of the clay body 196°C. In practice, a fair amount of this heat would be lost by heating the nitrogen and other inert gases of the kiln, but most of the heat would stay in the clay.

If the clay contained 1% of sulfur (1 gram in 100 grams of clay) as FeS_2, then $\frac{130{,}200}{64} = 2034$ cal. would be evolved. This would heat 100 grams of water 20.34°C, or the 100 grams of clay which contained this sulfur 50.8°C in theory and somewhat less in practice.

It is therefore evident that the danger of heating the clay too hot by the oxidation of impurities is nearly four times as great from carbon as from sulfur.

It would be well for the ceramic prospector to bear in mind that any clay containing pyrite and over 0.50% carbon will require slow and careful firing throughout the oxidation period. This would hold whether the sulfur as pyrite were 0.10% or 0.50%.

The saving in fuel and labor and the quicker turnover of kilns, thus increasing plant capacity, may well overbalance the greater cost of obtaining a different clay as raw material which contains less carbon.

VI. Water from Clay on Firing

It is necessary to add water to clay to make it plastic so that it can be given the desired form.[6] Theoretically, all of this water is removed by a drier before the ware enters the kiln. In practice, this is not always true. Almost every fuel used commercially contains some hydrogen, which, on firing, becomes water. Kaolin, the clay substance, also contains water of constitution, which seems to be released in relays at about every 400°C.

It is, therefore, impossible to prevent water from passing with the draft through ware in a commercial kiln. This draft, of necessity, passes from hotter to cooler ware. There is consequently a good chance for condensation of water. Unfortunately during the early stage of firing, the drawing power of a chimney is at its minimum efficiency since it is filled with damp air at no great temperature. With a downward draft, the bottom layers of the setting may become quite soggy and would be distorted by a heavy load. This is

[6] It has been found at a number of plants that the use of hard water is the source of scumming troubles. Changing to a different water supply, even rain water or distilled water, if necessary, has cured many a stubborn problem of scummed ware.

the reason for the relatively low height of down-draft kilns.

Trouble is courted by firing too heavily during this "watersmoking" period. If the liberation of sulfur oxides from the top of the setting begins while the ware at the bottom of the kiln is still wet with condensed water, the oxides will dissolve in the water-vapor as sulfurous and sulfuric acids and penetrate the ware. The top of the setting should be kept below 400°C, at least until the condensed water is driven out of the bottom layers of ware.

Common practice is to watch the top of the stack and note when the steam evolution decreases. Several hours are lost by this method, since condensed water in the flues must also be driven off before the signal is given.

This time can be saved and safety assured if a base-metal couple is inserted near the top and another near the bottom of the setting. If their temperatures are read and recorded every hour, the fastest possible safe heating schedule can soon be developed.

NOTE: In tunnel-kiln firing, this problem may become acute. The writer once saw a tunnel kiln where ornamental red tile was being fired. Sulfur trioxide was being evolved and drawn toward the charging end. On the way, it combined with water-vapor to form sulfuric acid. This acid was condensing on the kiln roof and dripping onto the recently charged ware. Each splash resulted in a pink spot on the finished ware; 25% of the finished ware was being culled on this account.

The removal of water from ware under fire should be a process separated as completely as possible from the elimination of sulfur by oxidation.

VII. Sulfur from Fuel

Electricity as a heating agent for kiln firing is almost universally too expensive for heavy clay products as also is wood. This eliminates the only two common sources of sulfur-free heat. Natural gas is frequently free from sulfur and fuel-oil is more rarely so, but the great volume of heavy clay products is fired with bituminous coal. And the great majority of bituminous coals contain from 0.5 to 5.0% of volatile sulfur. Moreover, there is a natural tendency to use coals higher in sulfur and consequently less expensive for kiln firing, selling the less obnoxious varieties for use in regions more thickly settled than the neighborhood of the ordinary brick or tile plant. Add to this the natural (but mistaken) tendency of the plant foreman to use the worst coal on hand for watersmoking. There thus is an additional problem to be faced, namely, that in the majority of kilns, during the period in which the effort is made to drive out sulfur gases from the ware, additional sulfur gases are being poured into the kiln. Water-vapor also is present in the products of fuel combustion. This makes possible the formation of those most active compounds, sulfurous and sulfuric acids.

There is always iron oxide present in the clays used in making heavy clay products. This will combine with the acids to form the sulfates of iron already referred to. Sulfur from fuel will therefore increase any sulfur problem that may already exist or it may be the main cause of the problem.

Actual figures will show the extent of this trouble. One kiln studied held 140 tons of ware and required 45 tons of coal to fire it. The ware contained 0.30% sulfur, the coal 1.8%. Thus there were 840 pounds of sulfur contained in the ware and 1620 pounds in the coal. In another kiln with a sulfur problem, 1230 pounds of sulfur were contained in the ware and 1693 pounds of sulfur in addition entered with the fuel gases. Much of this sulfur condensed on the surface of the ware and consequently increased the time required to remove sulfur.

Such delays increase the fuel and labor cost of firing and, by lengthening the firing time, reduce the plant capacity. A "dollars-and-cents calculation" will show that when a clay requires a slow firing schedule the use of a low-sulfur coal during watersmoking will more than pay for its extra cost.

VIII. Remedy

The remedy for this and all other sulfur troubles is more draft and still more draft. If enough oxygen is furnished to the ware to oxidize it completely as rapidly as it is ready to oxidize, much trouble and time will be saved. The very act of furnishing enough oxygen will furnish enough draft to remove sulfur oxides rapidly from contact with ware at a temperature eager to absorb them. It will simplify, if not solve, the whole problem.

IX. Recovery of Sulfur

No chemical or ceramic engineer could see such a quantity of sulfur going to waste, and often creating a nuisance, without trying to recover it. In the cases quoted, there would be the equiva-

lent of six or seven tons of commercial-strength sulfuric acid given off for each kiln fired. And much of it is in that form already.

The problem has been encountered and solved in other industries where sulfur-bearing ores are smelted. The electric precipitation process sounds as if it were made to order for the heavy clay products manufacturer with a sulfur nuisance.

Inquiry was made, giving the sulfur concentration in the stack of a commercial plant. Perhaps it was not a well-chosen case (a gas-fired tunnel kiln with 0.24% sulfur in the clay) but the answer was a surprise. The process was applicable only to much stronger sulfur concentrations.

That was nine years ago. Perhaps the process has been improved. There might be a different answer for an intermittent kiln with occasional bursts of heavy clouds of acid fumes.

Acknowledgment

Gratitude and thanks for advice and assistance are given to all those who were members of the Station staff during those years.

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DEVELOPMENT OF PROPOSED STANDARDS AND TESTS FOR PLASTER OF PARIS IN THE CERAMIC INDUSTRIES*

By Samuel J. McDowell

I. Introduction

The use of calcined gypsum or plaster of Paris has been known so long to man that the date of the discovery of its properties is unrecorded. Certain it is that the Assyrians and Egyptians used this material, and some plaster work in the pyramids of Egypt is in good condition today.

The discovery of gypsum in the United States was made in 1792 in New York state. A company was organized in 1808 to mine it for land plaster, but not until 1835 was the first plaster of Paris produced in this country. It is at present mined in at least eighteen states of the Union, but New York, Michigan, Ohio, Iowa, and Texas produce the greatest tonnage in about the order named.

The U. S. Bureau of Mines, in the year 1931 when the industry was using only about 25% of its production capacity, reported that 183,721 tons of plaster of Paris were sold to the ceramic industries. In the architectural terra cotta industry one ton of plaster of Paris is normally used for every three or four tons of the product manufactured, so that it is probably the second of the various raw materials in cost. In the whiteware industries it is not quite such a large relative factor in production cost even though those industries use a greater tonnage.

It seems unusual that standard methods for testing this important ceramic raw material, similar to the tests which have been adopted by the American Ceramic Society for testing clay and other raw materials, should not be in common use, so that results obtained by one laboratory or plant could in part at least be compared with others. Certain methods and standards for testing plaster of Paris have been adopted by the American Society for Testing Materials, as noted later, but some of these tests require equipment which is not normally in possession of a plant control laboratory. Having come in contact with this problem in industry, the writer has attempted to develop and check such tests in the hope that this might prove the starting point from which would eventually evolve standards and tests which could be adopted by The American Ceramic Society for this material.

* Received March 13, 1934.

II. Formation of Gypsum, Manufacture, and Setting of Plaster

There are various theories regarding the geologic formation of gypsum. It may have been formed by direct evaporation of sea water or basins already concentrated. There is also the possibility of spring deposits and the action of sulfurous waters in limestone. Regardless of the exact geologic process of formation, various quite pure and large deposits are available.

The gypsum is calcined in kettles or rotary calciners. Most of the material used in the ceramic industry is manufactured by the former method and first settle (128°C) material is usually used.

There are also differences of opinion as to the chemistry of setting of plaster of Paris. The original theory of Le Chatelier gave way to the colloidal theory, but at present most investigators have returned to the original theory with some slight variations.

III. Test on Plaster of Paris Samples

(A) Samples of Plaster of Paris Tested

(1) Terra Cotta Plaster

From the U. S. Gypsum Co., Oakfield, N. Y. The sample was secured through the courtesy of the Corning Terra Cotta Co., Corning, N. Y. The geology of this deposit is given in the *N. Y. State Museum Bull.*, No. 283. The sample has the following characteristics as given by the U. S. Gypsum Company:

Typical Analysis

	(%)
$2CaSO_4 \cdot H_2O$	86.01
Iron and alumina	1.04
Silica and insolubles	2.74
$CaCO_3$	6.50
$MgCO_3$	3.95

It is "aridized" and calcined to first settle. The setting time is 25 to 35 min., the consistency, 64 cc. (fresh), and the fineness, 92 to 96% through 100-mesh.

(2) Castaway Pottery Plaster

Handled by R. K. Vanderbilt, New York, N. Y. The sample was furnished through the courtesy of the Westinghouse Electric and Manufacturing Co., Porcelain Division, Derry, Pa., who use this material. It has the following characteristics as given by the Certain-teed Products Corporation, who mine and process at Blue Rapids, Kans.

Typical Analysis

	(%)
$2CaSO_4 \cdot H_2O$	99.3
Excess water (H_2O)	0.2
Shale	0.4
Dolomitic limestone $(CaMg)CO_3$	0.1

The normal consistency is 56 to 57. It is manufactured by the first settle process and is specially treated. The deposit lies interbedded with limestones and shales of the Permian series. It is at an elevation of approximately 20 feet above the Cottonwood limestone which is at or close to the division between the Permian and Pennsylvanian.

(3) East Chicago Terra Cotta Plaster

This sample was furnished through the courtesy of the U. S. Gypsum Company, Chicago, Ill., and the properties as given by that company are as follows:

Typical Analysis

	(%)
$2CaSO_4 \cdot H_2O$	93.29
Iron and alumina	0.44
Silica and insolubles	2.14
$CaCO_3$	1.93
$MgCO_3$	1.44

It is "aridized" and calcined to first settle. The setting time is 25 to 35 minutes, the consistency, 64 to 68 cc. (fresh), and the fineness, 92 to 96% through 100-mesh.

The gypsum is mined near Alabaster, Mich., north of Saginaw bay on Lake Huron. The deposit lies in the Mississippian system, and is 23 feet thick. It is covered with 10 feet of boulder clay.

(4) Ivory Pottery Plaster

Furnished through the courtesy of the U. S. Gypsum Company, Chicago, Ill., and mined by this company at Southard, Okla. The physical properties as given by them are as follows:

Typical Analysis

	(%)
$2CaSO_4 \cdot H_2O$	99.06
Iron and alumina	0.16
Silica and insolubles	0.48
$CaCO_3$	0.32
$MgCO_3$	Trace

It is "aridized" and calcined to first settle. The setting time is 30 to 40 min., the consistency, 58 to 60 cc. (fresh), and the fineness, 98% through 100-mesh.

The gypsum of Oklahoma is Permian in age and is found in "red beds" which extend from Texas through western Oklahoma into Kansas. The mineral is found in beds of rock gypsum which in places reaches the thickness of 60 feet. The gypsum is selenitic and the texture is coarsely crystalline.

(5) Pioneer Pottery Plaster

This sample was furnished through the courtesy of the Best Bros., Keene Cement Company, Medicine Lodge, Kans., who furnished the analysis.

Typical Analysis

	(%)
$2CaSO_4 \cdot H_2O$	99
$CaCO_3$	1

The fineness is 99.9% through 100-mesh, 98.4% through 150-mesh, and 91.0% through 200-mesh.

The testing consistency is about 53 cc. This is second-settle material produced in rotary kilns. The rock is massive gypsum 22 to 26 feet thick, occurring in the upper strata of the Permian on top of the Permian "red beds." It is very white and contains no anhydrite. It is mined by underground methods, as it carries a 6-foot shelf of sandstone above the gypsum.

(6) Pioneer Dental Plaster

This was furnished through the courtesy of the Best Brothers Keene Cement Co., Medicine Lodge, Kans. It is similar to (5) except for slightly different processing.

(B) Test Procedure

From a review of the literature, the first step in this investigation should be the determination of proper standard methods for obtaining the same consistency. This would necessarily have to be simple enough so that it could be repeated in control laboratories of ceramic plants. Apparatus

like the Southard viscosimeter or the modified Vicat needle, such as have been and are at present used in the A.S.T.M. specifications, are not of this type. In fact, McAnally states that while it is essential to have a definite consistency for the mix for strength tests, there is no common standard adhered to even in the gypsum industry itself. A few laboratories have the consistency testing equipment noted above but their use in gypsum plants is rare.

A test similar to the field method in the A.S.T.M. standard method of testing gypsum and gypsum products, however, was tried and with some variations proved to be quite satisfactory. This consisted of filling a two-inch brass pipe ($2^1/_{32}$ inches inside diameter) and 4 inches high with the plaster-water mixture on a glass plate, raising the pipe, and allowing the plaster to slump. The pipe was cut off true and square on both ends. An attempt was made to have the pipe and glass plate wet as called for by the A.S.T.M., but results could not be checked and thereafter both the pipe and glass were used clean and dry.

Three hundred grams of plaster were found to be best as this mixed well and filled the pipe. For a standard method of mixing, a round-bottom glazed mixing bowl was used and the water placed in it. The plaster was added directly but this resulted in a lumpy mix so the plaster was later added through an 8-mesh screen. In all cases the plaster and water were allowed to stand two minutes before mixing. This was a satisfactory period and is the same as specified in the A.S.T.M. field test.

The mixing operation was confined to a one-minute period as longer mixing caused the plaster to become too stiff and a shorter period gave danger of lumps. At the suggestion of A. S. Watts,[1] an egg beater of the flat type was first used. The two blades followed the shape of the bowl and cleared it by about $^1/_8$ inch. The speed was varied from 60 to 100 revolutions per minute. This method of mixing was abandoned in favor of hand mixing as there were fewer lumps with the use of a spatula or trowel and the hand stirring was maintained at the rate of 120 revolutions per minute.

The size for the resultant round plaque to designate the testing consistency was adopted as 6 inches in diameter $\pm^1/_4$ inch, because plaster with this amount of water worked well and gave a strength somewhat near that attained when 60 cc. of water were used.

The temperature of the water was varied from 15 to 30°C (59 to 86°F) without noticeably affecting the test and distilled water was used instead of Columbus, Ohio, city water with no appreciable change.

The following group of check runs was made on the same plaster, using a consistency of 60 to find the variation in the method:

ID = $6^3/_8$-in. diameter, very round plaque; cylinder raised in 1 to 2 sec.
IF = $6^1/_8$-in. diameter; cylinder raised in 1 to 2 sec.
IG = $6^9/_{16}$-in. " " " rapidly.
IH = $6^1/_{16}$-in. " " " in 1 to 2 sec.
IJ = $6^1/_4$-in. "
IK = $6^1/_4$-in. "
IL = $6^3/_{16}$-in. " } cylinder raised in 1 to 2 sec.
IM = $6^1/_8$-in. "
IN = 6-in. diam. "
IO = $7^1/_2$-in. diameter; cylinder raised very rapidly.
IP = $6^5/_{16}$-in. " " " in 1 to 2 sec.
IQ = $6^1/_{16}$-in. " " " rapidly.

It will be seen from these tests that consistent results can be obtained by uniform procedure. The greatest difficulty was found in raising the cylinder too rapidly so that there was a tendency for the plaster to splash.

The accuracy of the method is shown by the following effects of changes in consistency with the same plaster:

	Consistency (cc.)	Size of resultant plaque (in.)
2E	58	$5^1/_2$
2O	59	$6^1/_{16}$
ID	60	$6^3/_8$
2M	61	$7^3/_8$
2G	62	8

This would indicate that the method has an accuracy of ± 1 cc., particularly if the results are checked once.

Approximately 125 determinations was made by the method recommended, checking various points. It seems to apply very well to fluffy and "plastic" plasters like those used in the pottery and terra cotta industries, but it is not so applicable to lean plasters of low plasticity.

(1) Consistency

The results of consistency tests on the various plasters as received were as follows: A 59, B $63^1/_2$, C 62, D 59, E 65, and F 61. All results were checked at least twice.

Additional experimentation on this subject was stopped in January, 1932, and not continued until

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November, 1932. Samples of each of the plasters were kept in dry, but not air-tight containers. Since the various materials were one year old at this time, it was decided to check some of the physical properties and compare them with the previous results.

A comparison of the consistencies of the new and old plaster is as follows:

	Consistency		
	1931	1932	Difference
A	59	58	−1
B	63½	61	−2½
C	62	59	−3
D	59	59	0
E	65	64	−1
F	61	59	−2

These results check those of previous investigators in that aged plaster requires less water. This is probably due to the fact that a portion of the plaster, in calcining, has been heated to the temperature where the chemically combined water was driven off and what is called soluble anhydrite ($CaSO_4$) was formed. This material gradually rehydrates in the air to the hemihydrate.

(2) Fineness

Since the Tyler screens are standard with the American Ceramic Society, the following were chosen for testing these plasters as they compare most closely with the A.S.T.M. screens used:

28-mesh	Opening 0.0232 in.
60- "	" 0.0087 "
100- "	" 0.0058 "
200- "	" 0.0029 "

A 100-gram sample of each of the plasters was placed on the 28-mesh screen, which was the top of the nest. The screening was done with as little abrasion as possible. When the top screen was clean, or all the material possible had passed through, it was removed and its contents weighed while the screening continued through the remaining sieves.

Duplicate samples were screened through the same sieves on a Rotap machine, and the screening was continued until not more than 0.1% would pass through in one minute of hand screening. With the finer plasters (B, D, E, and F) it required from 60 to 70 minutes to complete the 200-mesh screening, which is probably too long from an abrasion standpoint, although the 100-mesh screening was completed in from 10 to 20 minutes.

An attempt to obtain a wet screening was also made although it was realized that some of the material would go into solution. The sample was placed on the screen and held under the faucet for two minutes for each test. The residue was dried at 100°F and weighed. The results were multiplied by 0.843 because the plaster had been converted into gypsum by combining with water.

The following table gives a résumé of screening results for the six plasters:

TABLE I

Sample		Total retained on 28-mesh		60-mesh		100-mesh		200-mesh
		Original	Check	Original	Check	Original	Check	Original
A	Dry by hand	0	0.1	1.8	1.8	5.8	5.0	14.5
	Rotap	0.1		1.4		4.5		11.3
	Wet	< .1		1.3		3.4		9.3
B	Dry by hand	< .1	0.1	0.5	0.4	5.3	2.6	18.0
	Rotap	0		0.1		2.3		15.5
	Wet	0		0.1		1.3		9.3
C	Dry by hand	< .1	0	0.6	0.7	4.8	4.2	16.0
	Rotap	0		0.4		3.8		14.1
	Wet	0		0.3		3.7		16.3
D	Dry by hand	< .1	0	0.6	0.6	2.4	3.3	12.3
	Rotap	0		0.1		1.7		11.7
	Wet	0		0.2		0.9		9.0
E	Dry by hand	0	0	0.1	0.2	1.3	1.8	8.1
	Rotap	0		0.1		0.9		8.0
	Wet	0		0.0		0.3		4.6
F	Dry by hand	0	0	0.1	0.1	1.4	1.4	7.9
	Rotap	0		< .1		1.0		11.2
	Wet	0		0		0.4		4.6

It would seem from these results that hand screening was the most satisfactory as the check ran fairly close except in the case of 100-mesh sample B where it appears that an error was made either in weighing or in judgment as to when the screening was complete. Checks were not run on the 200-mesh screen. It appeared that both the Rotap and the wet method gave abnormally low results. With the Rotap this was probably due to abrasion. In the wet method it was probably due to partial solution.

(3) Modulus of Rupture

Experiments were carried on to determine the moduli of rupture on a 5-inch span of the various plasters, but nothing of unusual character developed.

NOTE: A standard method for testing, as the result of this work, was presented for discussion before the Terra Cotta Division of the American Ceramic Society at the Meeting in Washington, D. C., February, 1932. It was generally felt by members of this Division that there was a real need for such standards, and considerable discussion resulted.

When work was resumed on the year-old plasters in 1932, bars were made in the same way as before and the modulus of rupture was determined. Table II shows a comparison of the tests for 1931 and 1932. It will be noted that the strength of the aged plaster was in some cases as much as 47% greater than the material as received. It is therefore evident that storage in a dry place, at least up to a year, produces a stronger plaster. There also seems to be less variation in the aged materials as there are fewer bars falling outside of the 15% maximum or minimum limits. It would appear from this that tests should be made at a definite age to be comparable.

TABLE II

Plaster	Consistency	No. of bars	No. bars outside 15% limits	Modulus of rupture (1931) (5-in. span)	No. bars	No. bars outside 15% limits	Modulus of rupture (1932) (5-in. span)	Increase in strength by storing plaster one year (%)
A	60	10	1	805	12	1	1097	25.5
A	STC	12	2	797	11	1	1172	47.0
B	60	12	0	942	12	0	995	6.0
B	STC	12	2	930	11	0	1225	31.7
C	60	12	1	972	11	0	1176	21.0
C	STC	10	0	855	12	1	1106	29.4
D	60	12	5	1038	12	1	1305	26.6
D	STC	12	2	1126	12	1	1317	17.0
E	60	11	3	1056	10	0	1233	16.8
E	STC	12	1	1014	10	2	1156	14.0
F	60	12	2	950	12	1	1265	33.2
F	STC	12	2	1000	12	0	1244	24.4

STC = Standard Testing Consistency.

In order to get additional information regarding plaster which might be important from the ceramic point of view. it was decided to determine the absorption as well as the transverse strength of both the dry and water-saturated bars using, the broken bars $3^1/_2$ inches long for these tests.

(4) Absorption

To check the absorption of some of the pieces, bars of the recently made A60-mix were dried at room temperature, weighed to the nearest 0.1 gram, soaked in city water at room temperature, and weighed at intervals.

There was evidently an early soaking up of the water in one hour or less and very little change from that point on to 48 hours. In order to check further action, the water was heated just to the boiling point, but in every case this caused loss in weight undoubtedly showing solution.

TABLE III

Plaster	Consistency	Av. modulus of rupture 5-in. span (dry)	Strength (%)	Av. modulus of rupture 3-in. span (dry)	Strength (%)	Av. modulus of rupture 3-in. span (wet)	Strength (%)	Av. absorption (%)
A	60	1097	100	960	87.5	419	38.2	29.9
A	STC	1172	100	1086	91.3	470	39.5	28.6
B	60	995	100	930	93.5	417	42.0	34.0
B	STC	1225	100	1197	97.5	540	44.0	28.6
C	60	1176	100	1192	101	471	40	25.0
C	STC	1106	100	1121	101.3	481	43.5	23.8
D	60	1305	100	1397	107.0	562	43.0	25.4
D	STC	1317	100	1275	97.0	599	45.5	24.7
E	60	1233	100	1250	102.0	593	48.4	25.6
E	STC	1156	100	1101	95.5	572	49.5	28.8
F	60	1265	100	1204	95.5	618	49.0	26.3
F	STC	1244	100	1264	101.7	630	50.6	25.7

It was decided to proceed as follows with this test: (*a*) Dry the test specimen at room temperature until the weight is constant; weigh to the nearest 0.1 gram. (*b*) Submerge the test specimen in water for a period of one hour. The water temperature shall be that of the room (70 to 80° F). The test specimen shall be removed, the surface wiped with a damp cloth, and weighed

immediately. The per cent absorption shall be calculated on the dry-weight formula.

$$\text{Absorption } (\%) = \frac{100\ (B - A)}{A}$$

Where A = weight of dry specimen.
B = weight of wet specimen.

Table III shows a comparison between the averages for these various plasters and the comparative percentage strength, using the 5-inch span results as 100%. The average per cent absorptions are also given.

As the results for plaster of Paris B (consistency 60) were consistently low in strength and abnormally high in absorption, it was decided that a mistake must have been made in weighing, but no check tests were made.

(C) Conclusions

It appears that a somewhat better comparison of the physical properties of plasters can be obtained if standard testing consistency is used rather than a consistency of 60. It is realized that a decided increase in strength can be obtained by use of a mechanical mixing device. Since it would be extremely difficult to specify one which could be duplicated in different plants, carefully controlled hand mixing is suggested.

The same is true of fineness tests. Any mechanical device such as the Rotap is labor-saving, but with a soft material serious errors may result.

Modulus of rupture tests on the soaked bars seem a valuable aid in comparing different plasters since the wear on plaster molds, particularly in the terra cotta industry, is due to the weakened condition of the wet plaster.

Taking these items into account, the following specifications and tests are suggested.

IV. Suggested Tentative Specifications for Terra Cotta Plaster and Standard Methods for Testing

(*1*) *Definition:* Gypsum terra cotta plaster is a material consisting of calcined gypsum for use in making terra cotta models and molds.

(1) Properties

(*1*) *Composition:* Gypsum terra cotta plaster shall contain not less than 85% of calcined gypsum ($CaSO_4 \cdot {}^1/_2H_2O$).

(*2*) *Time of Set:* The time of set for gypsum terra cotta plaster varies with the use. It can be controlled by the manufacturer to fit the needs of the user and therefore need not be covered by these specifications. In general, it varies between 20 and 40 minutes.

(*3*) *Fineness:* Gypsum terra cotta plaster shall all pass a 28-mesh screen (opening 0.0232 inch) and not less than 94% shall pass a 100-mesh screen (opening 0.0058 inch).

(*4*) *Dry Modulus of Rupture:* Gypsum terra cotta plaster shall have a dry modulus of rupture of not less than 700 pounds per square inch.

(*5*) *Soaked Modulus of Rupture:* Gypsum terra cotta plaster shall have a soaked modulus of rupture of not less than 400 pounds per square inch.

(2) Sampling

The sample obtained shall be representative of the material and shall be taken from the surface and center of each package selected. The material so selected shall be thoroughly mixed and quartered to produce a 15-lb. sample. This shall be stored in an air-tight container and tested as soon as possible. When comparing two or more plasters, they should be as nearly the same age as possible.

(3) Standards Methods for Testing

(*1*) *Fineness:* Fineness shall be determined by screening, by hand, 100 grams of dried sample through the screens specified, weighing the material remaining on each screen. The material shall be shaken through the screen with as little abrasion as possible until one minute of screening will no longer sift 0.1 gram through the screen.

(*2*) *Testing Consistency:* A sample of 300 grams shall be mixed with sufficient clean water at ordinary temperatures (60 to 90°F) to produce a mix of testing consistency according to the following slump test: A consistency of 60 or 180 grams of water shall be tried first and the direction of further trials determined. The plaster shall be sifted into the water through an 8-mesh screen. This shall be allowed to stand for two minutes and shall then be stirred with a clean spatula or trowel at the rate of 120 times per minute for one minute. The mix shall at once be poured to fill a clean dry brass cylinder (2-inch brass pipe, 4 inches long) standing on a clean dry piece of glass approximately 8 inches square. The cylinder shall at once be lifted vertically and the plaster allowed to

slump. The mixture shall be termed of testing consistency when the resultant pat has a diameter of 6 inches $\pm 1/4$ inch. This determination shall be checked and the consistency given in terms of the number of cubic centimeters of water per 100 grams of plaster.

(*3*) *Dry Modulus of Rupture:* Two thousand grams of plaster shall be mixed with sufficient water to make a paste of testing consistency and poured into ten molds, 1 by 1 by 7 inches. These shall be well oiled or greased and placed on a glass plate or a smooth table. The containing vessel shall be moved back and forth over the molds during pouring. The plaster in the molds shall be worked with the fingers to release air bubbles, struck off level, and allowed to remain in the mold until set. The test pieces shall then be removed from the mold and stored at least 2 inches apart in a room between 60°F and 100°F. They shall be tested after a minimum of seven days or when each piece does not lose more than 0.1 gram in twenty-four hours.

The actual breaking shall be carried out according to the tentative test for transverse strength of the American Ceramic Society standards on a 5-inch span. A variation of $\pm 15\%$ from the average modulus of rupture shall be permissible. Any bar that varies more than this from the average shall be discarded. In case more than three shall be discarded from one mix, the test shall be repeated. The modulus of rupture shall be the average of the accepted bars and shall be reported in pounds per square inch.

(*4*) *Percentage Absorption and Soaked Modulus of Rupture:* One-half of each bar tested above shall be weighed and then submerged in water for a period of one hour at a temperature of 70 to 80°F. The test specimen shall be removed, the surface wiped with a damp cloth, and weighed immediately. The percentage absorption shall be calculated on the dry-weight basis. The saturated pieces shall then be broken and the modulus of rupture determined on a 3-inch span as above.

V. Suggested Tentative Specifications for Pottery Plaster and Standard Methods for Testing

(*1*) *Definition:* Gypsum pottery plaster is a material consisting of calcined gypsum for use in making pottery molds.

(1) Properties

(*1*) *Composition:* It shall contain not less than 90% calcined gypsum.

(*2*) *Time of Set:* Same as noted under terra cotta plaster (Section IV (2)).

(*3*) *Fineness:* The plaster shall all pass a 28-mesh screen (opening 0.0232 inch) and not less than 94% shall pass a 100-mesh screen (opening 0.0058 inch).

(*4*) *Dry Modulus of Rupture:* It shall have a dry modulus of rupture of not less than 900 pounds per square inch.

(*5*) *Soaked Modulus of Rupture:* The modulus of rupture of water-saturated plaster shall be not less than 500 pounds per square inch.

Methods of sampling and testing shall be the same as given under terra cotta plaster (Section IV (2) and (3)).

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>
> When I think back over the past fourteen years, I realize the debt of gratitude I owe to Dr. H. Ries who gave me an application blank and sponsored my membership into the Society; and to Ross Purdy who saw to it that I was elevated to full membership two years later.
>
> Whatever progress I have made in my chosen branch of the ceramic industry during this period has been due in a very large measure to the technical knowledge I have acquired from the personal friendships I have made in the American Ceramic Society.
>
> There are many men in the ceramic industry who have not been trained as ceramists, yet they are doing splendid work in both the technical and executive divisions of their industry. These men should be given every opportunity to share in the numerous benefits and services obtainable through membership in the American Ceramic Society.
>
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Our record of New Members for 1935 is:

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Every issue of *The Bulletin* which reaches a nonmember increases his understanding of the services to be had by joining the American Ceramic Society. Help American ceramists "discover" the American Ceramic Society through *The Bulletin*, at $1.50 a year.

BRADLEY OF THE A. P. GREEN FIRE BRICK COMPANY SECURES SIXTEEN NEW PERSONAL MEMBERS FOR THE SOCIETY

RICHARD SMITH BRADLEY

Richard S. Bradley, Director of Research, A. P. Green Fire Brick Co., has secured sixteen new personal members for the American Ceramic Society during the last year.

Activity like this on the part of fifty other members would soon bring the Society back to its all-time high of 2700 paid personal memberships.

Other persons whose activities have resulted in many new memberships during the past year (July, 1934 to June, 1935) are as follows:

Adcock, A. S.	1	Baggs, A. E.	1	Barker, G. J.	1
Babcock, M. G.	1	**Bales, C. E.**	2	Blau, H. H.	1
				Bleininger, A. V.	1
				Bowman, R. M.	1
				Bradley, R. S.	16
				Brian, George	1
				Carothers, R. B.	3
				Clark, W. M.	1
				Cohn, W. M.	1
				Couch, E. G.	1
				Cox, P. E.	2
				Curtis, T. S.	4
				Curts, R. M.	1
				Dodd, C. M.	3
				DuBois, H. B.	1
				Everhart, J. O.	2
				Flint, F. C.	5
				Franzheim, C. M.	1
				Freeman, C. A.	1
				Fulton, C. E.	1
				Gibson, F. G.	1
				Gould, R. E.	1
				Greaves-Walker, A. F.	9
				Greaves-Walker, A. M.	1
				Gregorius, J. S.	3
				Hansen, J. E.	1
				Hewitt, L. C.	1
				Hind, Stanley	1
				Hixson, J. W.	1
				Holmes, M. E.	4
				Hostetter, J. C.	2
				Humphreys, R. D.	1
				Irwin, D. D.	1
				Koos, E. K.	2
				Kraner, H. M.	1
				Landrum, R. D.	1
				Linder, C. S.	1
				Littleton, J. T.	5
				Loomis, G. A.	1
				Mattson, V. L.	1
				McAfee, W. Keith	2
				McCann, F. A.	1
				McComas, C. B.	2
				McKinley, J. M.	7
				McVay, T. N.	1
				Moulton, D. A.	2
				Nash, H. S.	1
				Norton, F. H.	2
				Oakley, W. W.	3
				Parmelee, C. H.	1
				Peddrick, C. H., Jr.	1
				Petrie, E. C.	1
				Pfeiffer, W. H.	1
				Porter, F. R.	1
				Robson, J. T.	1
				Roche, L. C.	1
				Rodgers, J. P.	1
				Roehm, V. J.	2
				Royal, H. F.	1
				Rusoff, S.	1
				Schramm, Edward	1
				Sherwood, R. F.	1
				Singer, Felix	1
				Sosman, R. B.	1
				Spencer, C. D.	1
				Stafford, W. L.	1
				Steger, Walter	4
				Stevens, F. J.	1
				Stolte, N. H.	1
				Strod, A. J.	2
				Sullivan, J. D.	1
				Sutphen, F. G.	2
				Tait, L. G.	1
				Taylor, N. W.	3
				Thomas, J. H.	2
				Van Schoick, E. H.	1
				Vaughan, W. H.	1
				Watts, A. S.	1
				White, H. E.	5
				Williams, F. J.	2
				Wilson, Hewitt	2
				Worcester, W. G	2

NEW MEMBERS

Personal

Arman, Clement C., Queen St., Georgetown, Ont., Canada; casting foreman and mold maker, Smith and Stone Ltd.

Crawley, E. J., 24 Kenwood Park Rd., Nether Edge, Sheffield, England; General Refractories, Ltd.

Eddy, Maxson A., Owens-Illinois Glass Co., Streator, Ill.; plant manager.

Erhardt, Ray K., 2405 61st Ave., Cicero, Ill.; ceramic engineer, Edison General Electric Appliance Co.

Shotland, Arch, Columbia Plate Glass Co., Blairsville, Pa.; secretary and treasurer.

Thiess, L. E., Porcelain Dept., General Electric Co., 1 River Rd., Schenectady, N. Y.

Turner, Donald, Messrs. Lodge Plugs Ltd., Rugby, England.

Weldon, Walter A., 621 Edgewood St., Baltimore, Md.

Witschey, R. A., Battelle Memorial Institute, 505 King Ave., Columbus, Ohio; scientific and industrial research.

Student

Bielski, Paul J., 605 Fifth Ave., Ford City, Pa. (Pennsylvania State College.)

MEMBERSHIP WORKERS' RECORD

Personal			
U. E. Bowes	1	W. E. S. Turner	1
E. T. Montgomery	1	H. E. White	1
Louis Navias	1	Office	2
F. R. Porter	1		9
		Student	
H. E. Simpson	1	N. W. Taylor	1
		Total	10

DATES FOR SUMMER MEETINGS OF DIVISIONS OF AMERICAN CERAMIC SOCIETY ANNOUNCED

Meeting in conjunction with other interested groups, four Divisions of the American Ceramic Society will present programs of interest to its members during the late summer and early fall of 1935.

The meetings (details of which will be announced later) are as follows:

Art Division

The Art Division will hold its Summer Meeting in Syracuse N. Y., from October 28 to 29, 1935, during the Fourth Annual Robineau Memorial Ceramic Exhibition. This Exhibition, which honors Adelaide Alsop Robineau is to be held at the Syracuse Museum of Fine Arts from October 15 to November 11.

R. Guy Cowan represents the American Ceramic Society on the Jury of Selection and Award. He is designer at the Onondaga Pottery Co., a Corporation Member of the Society.

Richard F. Bach, Director of Industrial Relations, Metropolitan Museum of Art, will deliver the opening address at the preview and reception of the Exhibition, October 14.

Glass Division

The Glass Division will hold its meeting again at Lake Keuka, N. Y., from September 13 to 14, 1935. Keuka Hotel will be the headquarters.

The first session will be held in the Keuka Hotel pavilion on Friday afternoon, with a brief second session on Friday evening, and a third session Saturday morning.

The members will assemble at Keuka Hotel, Keuka, N. Y., Friday morning for registration and for lunch. A dinner will be served at the Keuka Hotel Friday night. Members will also have lunch at this hotel Saturday noon.

A shore dinner will be held at J. T. Littleton's cottage Saturday night.

The following nine papers have been scheduled:

(1) The Effect of Sustained Loading on the Strength of Electric Lamp Bulbs, by F. W. Preston.
(2) Effect of Sustained Loading on the Modulus of Rupture of Flat Glass, by L. V. Black
(3) Proposed Method for Measuring Tensile Strength of Glass, by C. J. Phillips
(4) Geometric Form of Mechanical Strength Test Specimens, by George B. Watkins
(5) Factors Affecting the Impact Strength of Glass, by James Bailey
(6) Modulus of Rupture and Thermal Shock Resistance at Elevated Temperatures, by J. S. Gregorius
(7) Influence of Various Factors on the Results of Thermal Shock Tests, by Dr. Hampton
(8) The Influence of Various Heating and Cooling Media on the Severity of Thermal Shock on Glass, by G. R. Hunter
(9) Review of Recent Literature on Strength of Glass under Sustained Loading with Particular Reference to Borchard's Work, by J. T. Littleton

Refractories Division

Meeting at Penn State College, State College, Pa., September 20 and 21, 1935, the Refractories Division will present a program in conjunction with the Department of Ceramics at Pennsylvania State College and the Pittsburgh Section of the American Ceramic Society.

N. W. Taylor, head of the Department, Hobart M. Kraner, and Harold E. White of the Refractories Division, are in charge of arrangements.

A number of prominent metallurgists will present papers and discussions on refractories, speaking from the consumer's standpoint.

White Wares Division

On September 5 to 8, 1935, at New Brunswick and Beach Haven, N. J., the White Wares Division is planning to hold a Summer Meeting. This is the first summer meeting of this Division.

ROSTER CHANGES DURING JUNE*

Corporation

Northwestern Terra Cotta Co., Attn. B. Purcell, 1750 Wrightwood Ave., Chicago, Ill. (4417 Oleatha, St. Louis, Mo.)

Personal

Arnold, Howard C., 775 Shady Drive East, Pittsburgh, Pa. (Shields, Pa.)
Czolgos, Edmund P., Century Vitreous Enamel Co., 6641–6661 S. Narragansett Ave., Chicago (Clearing District), Ill. (Cleveland, Ohio)
Dietrich, Waldemar F., 683 Alvarado Row, Stanford University, Calif. (San Mateo, Calif.)
Dippell, Lawrence V., Pittsburgh Grinding Wheel Co., Rochester, Pa. (Abrasive Co., Philadelphia, Pa.)
Edwards, F. Moorland, Electrical Porcelain Plant, Carey, Ohio. (Akron, Ohio)
Ellis-Anwyl, Robert H., 328 Columbia Ave., Shreveport, La. (Camden, Ark.)
Fisk, Henry G., 3642 Washington St., Gary, Ind. (4614 Johnson St.)
Heath, Frederick, Jr., Apt. 106, 723 W. Onondaga St., Syracuse, N. Y. (104 Oak Place)
Hoven, W. J., 3034 Yorkshire Road, Cleveland, Ohio. (American Stove Co., 4101 Hough Ave.)
Jones, Richard E., Spruce St , Cheswick, Pa. (Tarentum, Pa.)
Kerr, Charles H., c/o R. B. Kerr, 18644 Irwin St., Reseda, Calif. (Jenkintown, Pa.)
Koupal, Walter G., Pittsburgh Plate Glass Co., Clarksburg, W. Va. (Creighton, Pa.)
Rhode, Irma, Norris, Tenn. (St. Louis, Mo.)
Siegrist, Paul F., 1035 Market St., Lewisburg, Pa. (Mifflinburg, Pa.)
Turner, Cecil H., 6734 Maple St., Mariemont, Ohio. (Crafton, Pa.)
Wedemeyer, N. G., Röhm & Haas Co., 222 W. Washington Square, Philadelphia, Pa. (Membership transferred from H. C. Kremers.)
Wills, George A., 105 Park Ave., Raleigh, N. C. (Rutgers University, New Brunswick, N. J.)

* Address in parentheses ( ) is the old address.

CHARLES FERGUS BINNS MEMORIAL SERVICE

Alfred, New York, June 8, 1935

With a program of addresses eulogizing Dr. Binns as a ceramist, a Christian minister, an educator, a faculty colleague, and a citizen, the ceramics building on the Alfred University Campus was dedicated and marked as Binns Hall on June 8, 1935. The family, former students, associates, and friends of Dr. Binns were there to honor his memory. Paul E. Cox delivered the memorial address.

Representing American ceramists, with President John M. McKinley as spokesman, the American Ceramic Society acknowledged the work of Dr. Binns in ceramic art and technology and his executive, spiritual, and academic leadership.

In reverence and as a token of appreciation of him who, though now silent, still inspires and leads, President McKinley placed a wreath on the grave of Dr. Binns. With a prayer of appreciation and a plea for divine guidance, several members of the Society witnessed the ceremony at the last resting place of Dr. Binns.

The New York State College of Ceramics gave to this convocation a national significance by granting professional degrees of Ceramic Engineer to William Keith McAfee, president of the American Ceramic Society in 1933–1934, and to Edward Schramm who has served the White Wares Division on the Board of Trustees during several different terms. The Doctor of Science degree was conferred upon Paul E. Cox (see this issue, page 244).

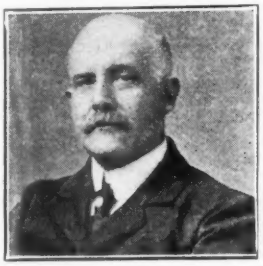
Concurrent with the ceremonies in Alfred, a memorial exhibition of pottery made by Dr. Binns was shown in the Metropolitan Museum of Art (Gallery J8). This exhibition was continued at the Museum from May 13 to June 9.

Several pages of the May, 1935 issue of *The Bulletin of the Metropolitan Museum of Art* were devoted to the personal history and achievements of Dr. Binns.

These stoneware vases are from the Memorial Exhibition of the work of Charles Fergus Binns, held at the Metropolitan Museum of Art, May 13 to June 9, 1935. The bowl was lent by the estate of Henrietta Crawford; the vase lent by Miss Elsie Binns. *Photo courtesy the Metropolitan Museum of Art.*

Albert Granger

Albert Granger, noted French ceramist, died March 30, 1935. His career in France was long and marked by many valuable contributions to the ceramic industry; for forty years he contributed to the training of ceramic technologists.



A. A. GRANGER

In 1894 Albert Granger was made professor of chemistry and ceramics at the school which had just been founded at the National Factory at Sèvres. From 1896 to 1910 he also served as director of ceramics. At that time he assumed direction of the testing service and held this position until the war.

The director of ceramics having been mobilized, he resumed his former position for the duration of the war.

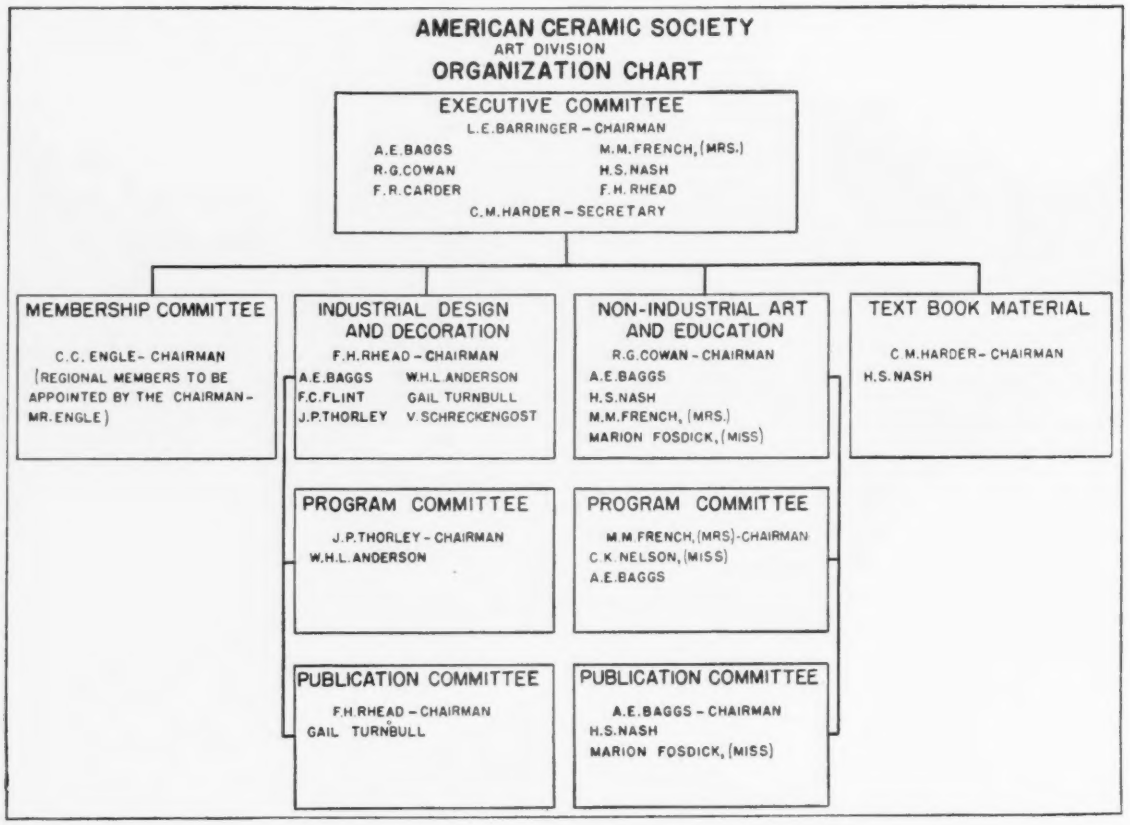
Later he was made instructor in the technology of ceramics, glass, and cement by the Director of the School of Physics and Chemistry. From here he proceeded to a chair at the Conservatoire des Arts et Métiers, and in 1924 he took charge of the ceramic course; later glass technology was added.

During the war he rendered valuable service in the construction and operation of large kilns for manufacturing articles for the chemical industry. Experiments with the firing of porcelain with liquid fuels and powdered coal were also under his direction.

His most important contributions, it is said, are in the research on a high-temperature blue and on the properties of tungsten anhydride as a ceramic color. His work on refractory products, the resistance of porcelain, and the industrial purification of cobalt oxide, as well as his work on the coloration of glass with copper oxide, the use of tungsten anhydride, and a very complete study of the colors obtained with selenium, sulfur, cadmium, and their compounds should also be noted.

He received many honors during his long period of service. Among these may be mentioned the French Chemical Society's award of the Leblanc Prize in 1900 and his honorary membership in the Chambre Syndicale de la Céramique et Verrerie since 1921, in which year he was also elected Honorary member of the Ceramic Society [England].

In 1935, a certificate of Honorary Membership in the American Ceramic Society was forwarded to him.



ART DIVISION PLANS ANNOUNCED

At the Annual Meeting of the Society in Buffalo, N. Y., last February, tentative plans were formulated for the reorganization and rejuvenation of the Art Division. It was planned so to modify the scope and activities of the Art Division as to interest and attract the many thousands of amateur and professional ceramic arts craftsmen throughout the country as well as ceramic art students, collectors, dealers, and others. The new Art Division organization is shown upon the accompanying chart.

One of the most important of the new activities of the Art Division is the securing of a list of prospects. This will be done by the Membership Committee, of which Chester C. Engle is chairman. Mr. Engle has issued a letter to American Ceramic Society members in twenty-eight districts of the country, these districts having been determined by the relative amount of ceramic activity within their boundaries, both industrial and nonindustrial.

It is estimated that there are approximately 2000 or more individuals, students, members of guilds, clubs, studio potters, museum workers, dealers, and others who should have some ground of common interest. When this list of prospects has been developed, invitations will be issued to them to attend the separate Art Division meetings and to subscribe to *The Bulletin of the American Ceramic Society*, either in whole or in part, as may be later decided.

The plans include the meeting of the Art Division at Syracuse October 28 and 29 and attendance at the National Ceramic Exhibition to be held at the Syracuse Museum of Fine Arts in Syracuse, N. Y., from October 15 to November 11.

It is also proposed that at least four numbers of *The Bulletin* be devoted to art subjects and definite arrangements have been made whereby the August, 1935, and February, 1936, numbers will be devoted to industrial art subjects issued under the direction of Frederick H. Rhead, while the November, 1935, and May, 1936, numbers will be devoted to nonindustrial ceramic art subjects to be issued under the direction of R. Guy Cowan.

Later on it is proposed to develop some sort of Art Division membership or affiliate membership whereby for $3.00 subscribers may have the privilege of attending Art Division meetings and may also receive either the four Art Division numbers of *The Bulletin* or the entire twelve issues of *The Bulletin*, as may seem best.

It is earnestly hoped that these efforts of the Art Division to cultivate an untouched field and to promote interest in the work of the Art Division of the American Ceramic Society will be endorsed and assisted by all members of the American Ceramic Society. To this end, suggestions will be welcomed by the undersigned upon any phase of the work under way.

It has been ascertained that in almost every town and city of the country there are one or more persons or organizations interested in ceramic art who are not at all in touch with the efforts of the American Ceramic Society and are not likely to be brought into contact with the Society except through some new plan as that being developed by the Executive Committee of the new Art Division organization.—LAWRENCE E. BARRINGER, *Chairman*

LOCAL SECTION NEWS

CALIFORNIA SECTION HEARS ARNOLD O. BECKMAN

At one of the most important meetings in the history of the California Section, Arnold O. Beckman of the California Institute of Technology presented a paper on the "Determination of Acidity." The meeting was held at the Institute on May 28 and was attended by a group of fifty.

Dr. Beckman opened his paper with a review of the fundamentals with respect to hydrogen-ion concentration for the benefit of the laymen present, and by means of graphic experiments he made clear the important distinction between "weak" and "strong" acids. There followed a series of experiments demonstrating the use of indicators and buffer solutions with warnings as to the limitations of the colorimetric method of p_H determination.

A demonstration was presented of a new electrometric instrument designed by Dr. Beckman in which a glass electrode is employed. In this system, determinations may be read in a matter of seconds to an accuracy of 0.01 p_H unit, entirely irrespective of suspended solids, poisoning constituents, or buffer substances which may be present in the slip. Determinations were made on a dozen or more samples.

In view of the large amount of work that is now being done in the Southwest with low-fire ceramic bodies of a chemical character, requiring entirely different manipulation from that accorded the usual triaxial composition, it is believed that Dr. Beckman's paper will prove to be of outstanding value to the industry in that it points the way to a positive plant control of the characteristics of the new pottery slips.—THOMAS S. CURTIS, *Secretary*

MICHIGAN NORTHWESTERN-OHIO SECTION

Twenty-two members of the Michigan-Northwestern Ohio Section of the American Ceramic Society met at Mt. Clemens, Mich., for a dinner meeting, June 17.

J. A. Callahan, General Manager, Plumbing Ware Division, Briggs Mfg. Co., Detroit, Mich., gave a talk on pressed steel enamelware as made by the Briggs Mfg. Co.

—MACON TRABUE, *Secretary*

Research Receives Westinghouse Award

"Correlation of Viscosity Measurements with Flow of Glass," by H. K. Richardson, published in three parts in *The Journal of the American Ceramic Society*, August, 1934, received the Westinghouse Outstanding Accomplishment Award for 1934, according to an announcement recently received at the Society's offices.

"The Big Bad Wolf," a featured ceramic decoration at the Annual Pig Roast of the University of Illinois Student Branch, May 7, 1935.

ILLINOIS STUDENT BRANCH PIG ROAST SCENE OF NOVEL PRESENTATION

At the Annual Pig Roast of the University of Illinois Student Branch of the American Ceramic Society held May 7, 1935, at Urbana, Ill., the ceramic wolf shown in the accompanying photograph was presented to Professor Parmelee.

The scale of the figure may be gaged by the fact that the little ceramic pigs in front of the wolf stand three inches high.

After speeches by various members of the faculty, H. G. Wolfram, Director of Research for Porcelain Enamel & Manufacturing Co., Baltimore, Md., a graduate of the University of Illinois in Ceramic Engineering, 1923, spoke on "Experiences of an Alumnus."

The new officers of the Student Branch, elected for the school year of 1935–1936 are as follows: *President*, Rexford Newcomb, Jr.; *Vice-President*, John B. Stevens; and *Secretary-Treasurer*, Walter M. Turner.—W. M. T.

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NOTES AND NEWS FOR CERAMISTS

MEMBERS OF THE AMERICAN CERAMIC SOCIETY HONORED AT MANY UNIVERSITIES DURING JUNE COMMENCEMENT EXERCISES

Paul E. Cox Receives Honorary Degree at Alfred University

Paul E. Cox, Head of the Department of Ceramic Engineering, Iowa State College, Ames, Iowa, received the honorary degree of Doctor of Science from Alfred University on June 10, 1935. Dr. Cox also delivered the main address at the Binns Memorial Service held June 8. (See page 241, this issue.)

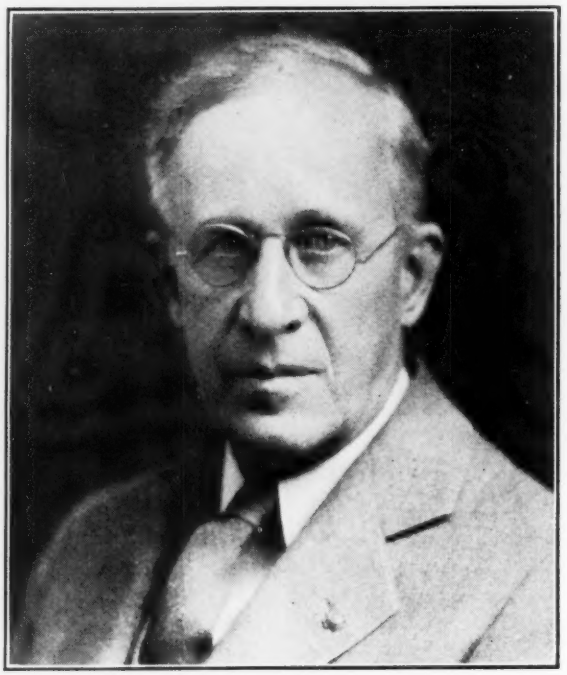
In his work in the Ceramic Department at Iowa State College, Dr. Cox has overcome many obstacles with the spirit of a true pioneer. His students, as a whole, come from a group that is self-supporting while in school, and oftentimes it is only through the kindliness and sympathetic ingenuity of Dr. Cox that they are able to remain in school.

In return for this understanding he offers to his students, he demands high standards of work both in their ceramic studies and in their character. Almost without exception the students of the Ceramic Department receive the highest recognition and honors when contesting with other groups in the Engineering School at Ames.

The Student Branch of the American Ceramic Society at Iowa State College, through Dr. Cox's interest, has become a compulsory activity of the ceramic students, with time regularly scheduled for this activity during the school day.

Every effort is made to interest the students in the educational value and social benefits of active membership in the Society.

Dr. Cox has served the Society for many years as an officer of the Art Division, and was Vice-President of the Society in 1930–1931.



PAUL E. COX

Paul E. Cox, Iowa State College, Ames Iowa, who received the honorary degree of Doctor of Science at Alfred University, June 10th at the 99th Commencement. He also delivered the main address at the Binns Memorial Service held June 8.

A. P. GREEN FIRE BRICK COMPANY PRESIDENT HONORED

Allen P. Green, president of the A. P. Green Fire Brick Co., Mexico, Mo., was awarded the degree of Doctor of Engineering, *Honoris Causa*, by the School of Mines and Metallurgy, University of Missouri, May 25, 1935, at commencement. The degree was conferred for outstanding contributions to the mineral industry of Missouri. Dr. Green is a former student of the School of Mines and Metallurgy.

A like honor was conferred on Dr. Green in 1933. (See *The Bulletin*, p. 28 (January, 1934).)

FRANK J. TONE HONORED BY UNIVERSITY OF PITTSBURGH

Frank J. Tone, president of the Carborundum Co., was awarded the honorary degree of Doctor of Science by the University of Pittsburgh, June 5, 1935. Mr. Tone was recently awarded the Edward Goodrich Acheson Medal.

Ceramic Association of New York Meets at Alfred

The second annual meeting of the Ceramic Association of New York was held at New York State College of Ceramics, Alfred, N. Y., June 7. Sixty people, from many different branches of the New York ceramic industry, attended.

In addition to the program previously announced in *The Bulletin*, p. 185 (May, 1935), F. E. Challis of the Industrial Management Council of the Rochester Chamber of Commerce spoke on the "Value of Dust Counting."

Officers for the coming year were elected as follows: *President*, Clarence Austin; *Vice-President*, J. C. Hostetter; and *Secretary-Treasurer*, M. E. Holmes.

George P. King, Great Lakes Portland Cement Corp., and E. V. Eskesen, Federal Seaboard Terra Cotta Co., were elected to represent, respectively, the cement and terra cotta interests on the Board of Directors.

—M. E. HOLMES, *Secretary*

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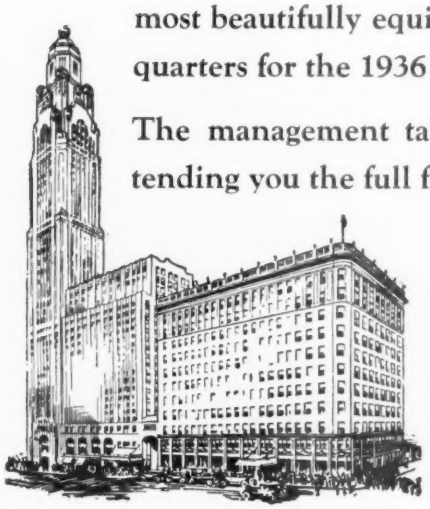

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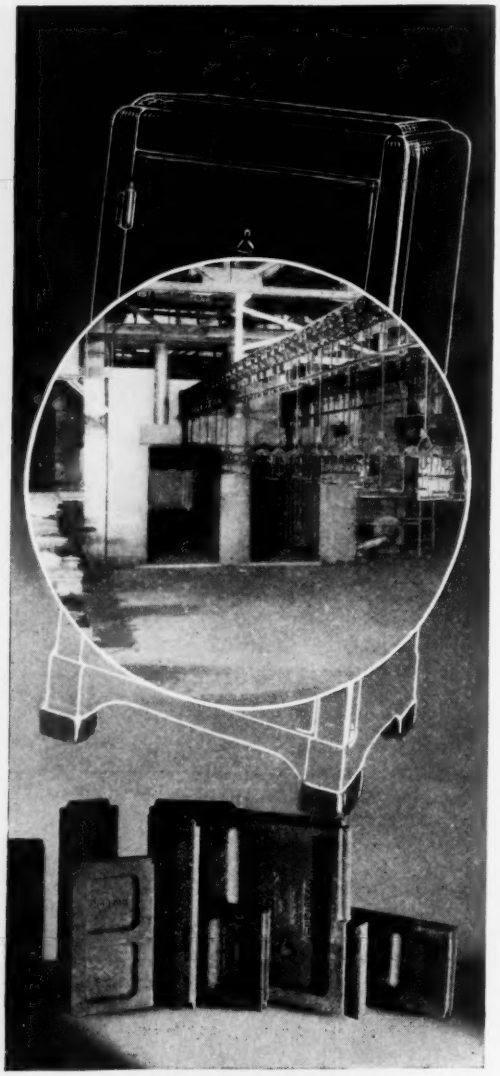

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R-503

1885 • Fiftieth Norton Year • 1935

NORTON PRODUCTS—Grinding Machines; Lapping Machines; Grinding Wheels; Abrasives for Polishing; Pulpstones; Laboratory Ware; Refractories; Porous Plates and Tubes; Non-slip Tiles, Treads and Aggregates; Behr-Manning Abrasive Paper and Cloth; Norton Pike Sharpening Specialties

Abrasives (Alundum-Crystolon)
Carborundum Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
Norton Co.

Air Conditioning Systems
Simplex Eng. Co.

Alorite (Refractory Products)
Carborundum Co.
Chicago Vitreous Enamel Product Co.

Alumina (Hydrate and Calcined)
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Aluminum Oxide (Fused)
Carborundum Co.
The Exolon Co.
The Hommel Co., O., Inc.
Norton Co.
The Vitro Mfg. Co.

Alundum (Refractory Products)
Norton Co.

Ammonium Bicarbonate
Solvay Sales Corp.

Ammonium Bifluoride
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Ammonium Carbonate
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.

Antimony Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Arches (Interlocking, Suspending, and Circular)
Simplex Eng. Co.

Ball Mills
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
McDanel Refractory Porcelain Co.
The Vitro Mfg. Co.

Ball Mills (Laboratory Type)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Barium Carbonate
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Batch Systems
Simplex Eng. Co.
Simpson Foundry & Eng. Co.

Batts
Carborundum Co. ("*Carbofrax Aloxite*")
Denver Fire Clay Co.
Norton Co. (*Alundum Crystolon*)

Bitstone
Consolidated Feldspar Corp.
Potters Supply Co.

Blocks (Refractory)
Carborundum Co.
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.
The Vitro Mfg. Co.

Borax
American Potash & Chemical Co.
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Pacific Coast Borax Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Borax Glass
American Potash and Chemical Corp.
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Pacific Coast Borax Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Boric Acid (Anhydrous)
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Pacific Coast Borax Co.
The Vitro Mfg. Co.

Boric Acid (Crystal, Granular, or Powder)
American Potash & Chemical Corp.
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Pacific Coast Borax Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Boron Carbide
Norton Co.

Brick (Refractory)
Carborundum Co. ("*Carbofrax Aloxite*")
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Norton Co
The Vitro Mfg. Co.

Carbofrax (Refractory Products)
Carborundum Co.
Chicago Vitreous Enamel Product Co.

Carbolon (Refractory Products)
The Exolon Co.

Carbonates (Barium, Lead)
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Castings (Abrasive Resisting)
Bethlehem Steel Corp.

Castings for Molds and Plungers
Simpson Foundry & Eng. Co.

Caustic Potash
Solvay Sales Corp.

Caustic Soda
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
The Hommel Co., O., Inc.
Pittsburgh Plate Glass Co.
The Roessler & Hasslacher Chemical Co.
Solvay Sales Corp.
The Vitro Mfg. Co.

Cements
Carborundum Co.
Chicago Vitreous Enamel Product Co.
Norton Co.
Pittsburgh Plate Glass Co.

Ceramic Chemicals
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
Metal & Thermit Corp.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Chromium Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Clay (Ball)
Ceramic Color & Chemical Mfg. Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Potters Supply Co.
The Roessler & Hasslacher Chemical Co.
Spinks Clay Co., H. C.
The Vitro Mfg. Co.

Clay (China)
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Edgar Brothers Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Clay (Electrical, Porcelain)
Ceramic Color & Chemical Mfg. Co.
Edgar Brothers Co.
Hammill & Gillespie, Inc.
Kentucky-Tennessee Clay Co.
Spinks Clay Co., H. C.

Clay (Enamel)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Edgar Brothers Co.
Ferro Enamel Corp.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Kentucky-Tennessee Clay Co.
Metal & Thermit Corp.
Paper Makers Importing Co.
Porcelain Enamel & Mfg. Co.
The Roessler & Hasslacher Chemical Co.
Spinks Clay Co., H. C.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Clay (Fire)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Edgar Brothers Co.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Pittsburgh Plate Glass Co.
Potters Supply Co.

Clay (German Vallendar)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
Porcelain Enamel & Mfg. Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Clay Miners
Edgar Brothers Co.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Spinks Clay Co., H. C.

Clay (Potters)
Denver Fire Clay Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
Spinks Clay Co., H. C.

Clay (Process Equipment)
Bonnot Co.

Clay (Sagger)
Edgar Brothers Co.
The Hommel Co., O., Inc.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Pittsburgh Plate Glass Co.
Potters Supply Co.
Spinks Clay Co., H. C.

Clay (Wad)
Kentucky-Tennessee Clay Co.
Potters Supply Co.
Spinks Clay Co., H. C.

Clay (Wall Tile)
Hammill & Gillespie, Inc.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Spinks Clay Co., H. C.

Clocks (Gauge Board)
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.

Cobalt Oxide
Ceramic Color & Chemical Mfg. Co
Drakenfeld & Co., B. F.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Colors
Ceramic Color & Chemical Mfg. Co
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Pittsburgh Plate Glass Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Cones
The Edward Orton, Jr., Ceramic Foundation

Conveying Equipment
Simplex Eng. Co.
Simpson Foundry & Eng. Co.

Cornwall Stone (Imported)
Consolidated Feldspar Corp.
Drakenfeld & Co., B. F.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Crucibles (Filter, Melting, Ignition)
Denver Fire Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.
Potters Supply Co.

Crystolon (Refractory Products)
Norton Co

Cullet, Washing Plants, Incinerators, Crushers
Simplex Eng. Co.
Simpson Foundry & Eng. Co.

Decorating Supplies
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Pittsburgh Plate Glass Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Drying Machinery
Ferro Enamel Corp.

Enameling Equipment (Complete)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Porcelain Enamel & Mfg. Co.

Enameling Furnaces
Carborundum Co. (*Carboradiant*)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Norton Co.
Porcelain Enamel & Mfg. Co.

Enameling Iron (Sheet)
American Rolling Mill Co.

Enameling Muffles
Carborundum Co. (*Carbofrax*)
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
Norton Co. (*Alundum*)
Pittsburgh Plate Glass Co.

Enameling (Practical Service)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Enamels
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Pittsburgh Plate Glass Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Enamels (Porcelain)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Equipment (Porcelain Enameling)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Porcelain Enamel & Mfg. Co.

Exolon (Refractory Products)
Ferro Enamel Corp.
The Exolon Co.

Feldspar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Finishing Tools
Simpson Foundry & Eng. Co.

Fire Brick
Carborundum Co.
Denver Fire Clay Co.
Ferro Enamel Corp.
Norton Co.

Fire-Polishing Machines
Simpson Foundry & Eng. Co.

Flint
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Flint Pebbles
Chicago Vitreous Enamel Product Co.
Consolidated Feldspar Corp.
Ferro Enamel Corp
The Hommel Co., O., Inc.

Floors (Non-Slip)
Norton Co.

French Flint
Consolidated Feldspar Corp.
Paper Makers Importing Co.

Frit
Allied Engineering Co.
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Fuel Oil Systems and Control, Stokers
Simplex Eng. Co.

Furnaces
Allied Engineering Co.
Carborundum Co. (*Carboradiant*)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Porcelain Enamel & Mfg. Co.

Glass Bending Ovens, Glass Decorating Machines
Simplex Eng. Co.

Glass Equipment
Hartford-Empire Co.
Simpson Foundry & Eng. Co.

Glass Melting Tanks and Furnaces
Simplex Eng. Co.

Glass Thickness Gauge
Bausch & Lomb Optical Co.

Glaze and Body Spar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Glazes and Enamels
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Glaze Spar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Goggles
Willson Products, Inc.

Gold
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Grinding Mills
Simpson Foundry & Eng. Co.

Grinding Wheels
Norton Co. (*Alundum Crystolon*)

Hearths
Carborundum Co.
(*Carbofrax* heat treating)
Norton Co. (*Crystolon*)

Hearths (High Aluminous Clay, Electrically Sintered Aluminum Oxide, Silicon Carbide)
Carborundum Co.
Norton Co.

Iron (Enameling)
American Rolling Mill Co.

Iron Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Kaolin
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Edgar Brothers Co
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.

Kettles of All Kinds
Simpson Foundry & Eng. Co.

Kilns, China (Decorating)
Allied Engineering Co.
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.

Kryolith
Ceramic Color & Chemical Mfg. Co.
The Hommel Co., O., Inc.
Jungmann & Co.,Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Ladles (Cast-iron)
Simpson Foundry & Eng. Co.

Leeds (High Aluminous Clay, Electrically Sintered Aluminum Oxide, Silicon Carbide)
Carborundum Co.

Lehrs
Simpson Foundry & Eng. Co.

Lehrs (Electric or Fuel Heated)
Simplex Eng. Co.

Lehr Loaders
Simpson Foundry & Eng. Co.

Linings (Furnace Refractory, Block Refractory Plate, Brick and Tile)
Carborundum Co.
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.
The Vitro Mfg. Co.

Magnesia (Sintered, Calcined)
Drakenfeld & Co., B. F.
The Exolon Co.
The Hommel Co., O., Inc.
Jungmann & Co. Inc.
Norton Co.

Magnesite
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.

Manganese
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co
The Vitro Mfg. Co.

Manganese (Oxide)
The Roessler & Hasslacher Chemical Co.

Masks (Breathing)
Willson Products, Inc.

Metals (Porcelain Enameling)
American Rolling Mill Co.

Microscopes (Polarizing)
Bausch & Lomb Optical Co.

Minerals
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co
The Vitro Mfg. Co.

Muffles (Furnace)
Allied Engineering Co.
Carborundum Co. (*Carbofrax*)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Ferro Enamel Corp.
Norton Co.
Pittsburgh Plate Glass Co.

Mullite (Artificial)
The Exolon Co.

Muriatic Acid
Denver Fire Clay Co.
The Hommel Co., O., Inc.

Nitrates (Cobalt, Sodium)
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Norbide (Norton Boron Carbide)
Norton Co.

Olivine
The Roessler & Hasslacher Chemical Co.

Opacifiers
Ceramic Color & Chemical Mfg. Co.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg Co.

Oxides
Ceramic Color & Chemical Mfg Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Pins
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
Potters Supply Co.

Polariscope
Bausch & Lomb Optical Co.
Simpson Foundry & Eng. Co.

Porcelain Enameling Service (Practical)
American Rolling Mill Co.
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Porcelain Enamels
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Potash (Carbonate)
Ceramic Color & Chemical Mfg. Co.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
The Roessler & Hasslacher Chemical Co.
Solvay Sales Corp.
The Vitro Mfg. Co.

Pot-setting Tools
Simpson Foundry & Eng. Co.

Presses, Side-lever and Bench
Simpson Foundry & Eng. Co.

Producer Glass Plants
Simplex Eng. Co.

Pyrometer Tubes (Refractory and Hard Porcelain)
Denver Fire Clay Co.
McDanel Refractory Porcelain Co.
Norton Co.

Pyrometric Cones
The Edward Orton, Jr., Ceramic Foundation

Raw Material Handling Equipment
Simpson Foundry & Eng. Co.

Refractometers
Bausch & Lomb Optical Co.

Refractories
Carborundum Co.
Denver Fire Clay Co.
The Exolon Co.
Norton Co.
Pittsburgh Plate Glass Co.

Refractory Materials
Carborundum Co.
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
The Exolon Co.
Kentucky-Tennessee Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.
Titanium Alloy Mfg. Co.

Respirators
Willson Products, Inc.

Rutile
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Saggers
Carborundum Co.
Norton Co.
Potters Supply Co

Salt Cake
American Potash & Chemical Co.

Saponin
Jungmann & Co., Inc.

Selenite of Sodium
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Selenium
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Sheets (Enameling Iron)
American Rolling Mill Co.

Silica (Fused)
The Exolon Co.
The Hommel Co., O., Inc.

Silicate of Soda
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
The Hommel Co., O., Inc.
Philadelphia Quartz Co.

Silicon Carbide
Carborundum Co.
The Exolon Co.
Norton Co.

Silicon Carbide Firesand
Carborundum Co.
The Exolon Co.

Sillimanite (Synthetic)
The Exolon Co.
Pittsburgh Plate Glass Co.

Slabs (Furnace)
Carborundum Co.
Norton Co.

Smelters
Ferro Enamel Corp.
Porcelain Enamel & Mfg. Co.

Soda Ash
American Potash and Chemical Corp.
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
The Hommel Co., O., Inc.
Pittsburgh Plate Glass Co.
The Roessler & Hasslacher Chemical Co.
Solvay Sales Corp.
The Vitro Mfg. Co.

Sodium Antimonate
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Sodium Fluoride
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Jungmann & Co., Inc
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Sodium Silica Fluoride
Jungmann & Co.

Soot Blowers
Simpson Foundry & Eng. Co.

Special Machines
Simpson Foundry & Eng. Co.

Spar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Spurs
Potters Supply Co.

Stilts
Potters Supply Co

Sulfuric Acid
Denver Fire Clay Co.
The Hommel Co., O., Inc.

Talc
Ceramic Color & Chemical Mfg. Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Roessler & Hasslacher Chemical Co.

Tanks (Pickle)
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.

Tanks for Raw Material Steel or Concrete
Simpson Foundry & Eng. Co.

Tile (Floor)
Norton Co.

Tile (Muffle)
Norton Co.

Tile (Refractory)
Carborundum Co. (*Carbofrax*)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.

Tile (Wall)
Denver Fire Clay Co.
Ferro Enamel Corp.

Tin Oxide
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Titanium
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Titanium Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Tubes (Insulating)
McDanel Refractory Porcelain Co.
Norton Co.

Tubes (Pyrometer)
Denver Fire Clay Co.
McDanel Refractory Porcelain Co.
Norton Co.
Pittsburgh Plate Glass Co.

Valves (Butterfly and Reversing)
Simpson Foundry & Eng. Co.

Water Softening Plants
Simplex Eng. Co.

Wet Enamel
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Whiting
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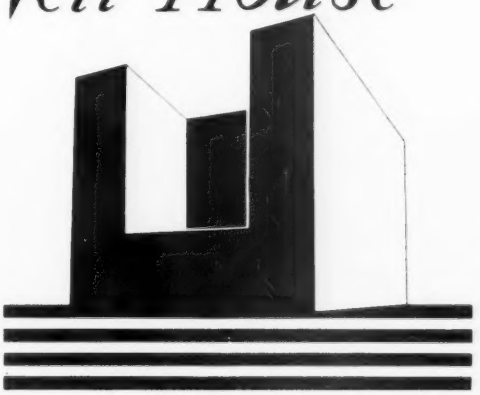

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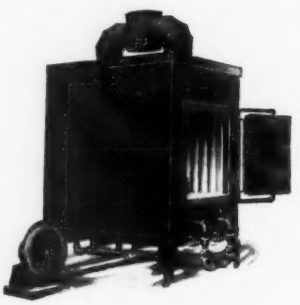

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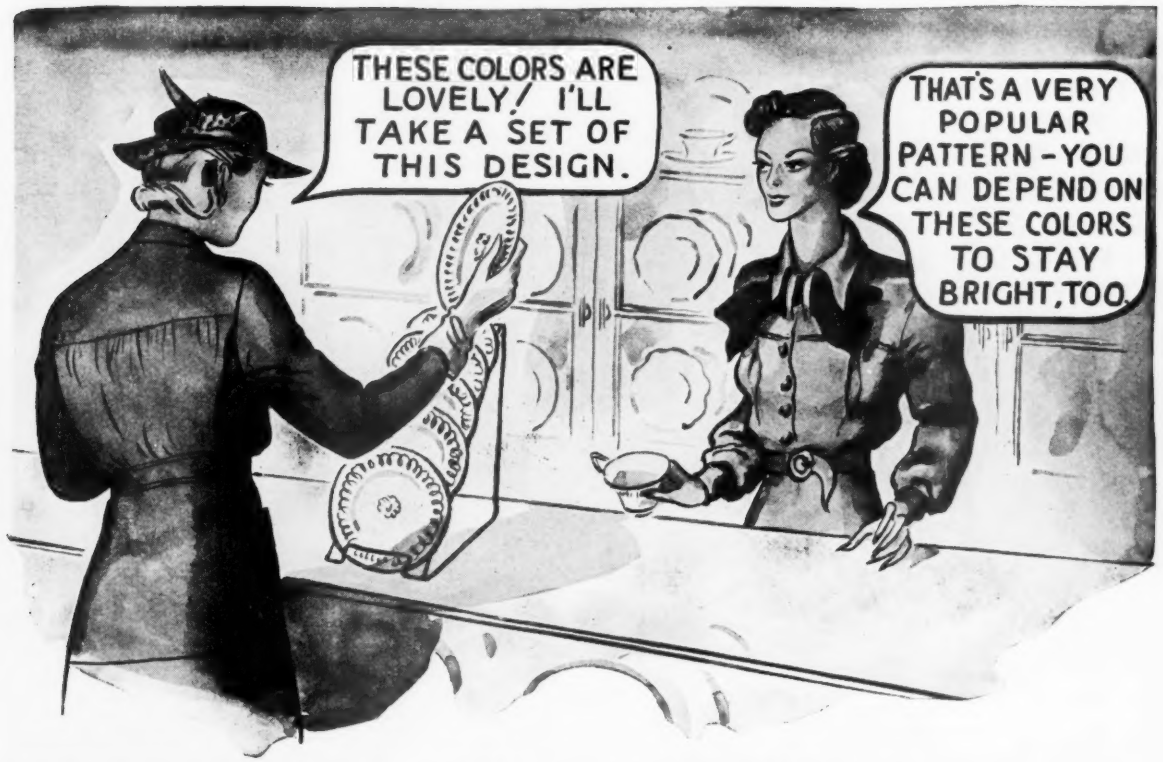
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